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THE STUDY OF SOLAR PROMINENCES.

FREDERICK SLOCUM.

The real study of solar prominences began in 1868, when Janssen and Lockyer independently discovered a method of observing the prominences in full daylight.

Previous to this time only brief glimpses of the objects had been obtained during total eclipses of the sun. Probably the first statement which can be interpreted as a reference to a solar prominence is found in a description of the eclipse of 1239 A.D. During the next six hundred years the accounts of eclipses occasionally contained brief mention of reddish spots, or clouds, or luminous points near the edge of the moon, but it was not until the eclipses of July 8, 1842 and July 28, 1851 that any reliable observations of the prominences were made.

During the latter eclipse it was noted that the moon passed over the prominences and revealed successive portions of them. This proved definitely that prominences are solar appendages, and, during the eclipse of 1868, some idea of their real nature was obtained. In that year the spectroscope was applied to prominences by various observers at different stations, with most important results. First, the prominences were found to give a bright line spectrum, indicating that they are composed of glowing gas. Secondly, part of the lines observed were identified as belonging to hydrogen. But most important of all, the experience obtained during that eclipse led to the discovery of a method of observing prominences without an eclipse. The discovery was made independently by two astronomers, Janssen, who was observing the eclipse in India, and Lockyer in England.

The only reason the prominences cannot be observed at any time, by simply holding up a screen to cut off the direct light of the sun, is that our atmosphere refracts and reflects the light of the sun, making the sky brighter than the prominences

themselves. To an observer on the moon, which is devoid of atmosphere, the prominences and corona, and even the stars by day, would appear against a black background of sky. Now Janssen and Lockyer discovered a method of reducing the glare of the sky without, at the same time, reducing the light of the prominences.

It had been noted that the prominences gave a discontinuous or bright line spectrum. That is, if viewed through a prism, a prominence would present several images of different colors, red, yellow, blue, etc., due to the light of hydrogen, helium and calcium. These images would be arranged along a line, and would be separated by appreciable intervals. If greater dispersion were used, that is, if a second prism were added, or a grating introduced, the distances between the various images would be increased, but their brightness would not be sensibly affected.

The light of the sky, on the other hand, gives an entirely different type of spectrum. It consists of fine dark lines projected against a continuous bright spectrum. If the dispersion is increased, the total light is spread out over a greater area, and, therefore, the brightness of any one part is reduced.

Moreover, the sky light gives dark lines exactly where the prominence gives bright lines. Thus, by using a spectroscope of high dispersion, it is possible to see the prominences projected against a relatively dark background. For ordinary purposes the slit of a spectroscope is made very narrow, in order that the spectral lines may be fine and sharp, but for this purpose the slit may be opened somewhat so that the whole of a small prominence, or a considerable portion of a large prominence, may be seen between the jaws. If widened too much, the background becomes too bright, so, in the case of large prominences, it is necessary to study them in sections. For such observations the slit of the spectroscope is placed tangential to the sun's limb, and, by rotating the spectroscope through 360°, the whole limb may be examined.

This method of observing prominences was discovered in the autumn of 1868, and from that time on daily observations of prominences were made in various places. In Italy a society was formed with the expressed purpose of studying the phenomena at the edge of the sun. Their publications, *Memorie della Società degli Spettroscopisti Italiani*, contain a practically continuous record of prominences for the past forty years. The observations were made visually, using a spectroscope with

wide slit placed tangential to the sun's limb. The published records are free hand drawings, showing the location and approximate form of all prominences for each day and detailed drawings of unusually large and active prominences, to show changes in form and size. At the same time important but less systematic work of the same nature was being done in England, Austria, Germany and the United States.

From these visual observations, two distinct types of prominences were distinguished, the quiescent and the eruptive. These were observed to differ, not only in shape and activity, but also in composition and distribution. The quiescent prominences generally assume forms resembling clouds, or trees, or groups of trees. In size they vary greatly. Some attain the enormous height of several hundred thousand miles, while others are even less than a thousand. In lateral extent there is a corresponding difference. Some cover fifty degrees or more of the sun's limb, while others may be confined within the limits of a single degree. In this type of prominences, as the name implies, the changes are comparatively slow, and yet at times there are remarkable exceptions to this rule. A prominence which has remained quiescent for several days may suddenly undergo some internal upheaval or explosion and be completely annihilated in a few minutes. The spectrum of these prominences shows that they are composed almost exclusively of hydrogen, helium, and calcium. They are found in all latitudes, but a careful tabulation of the observations of many years shows principal maxima between 20° and 25° latitude in both hemispheres, corresponding roughly with the positions of maximum sun-spot frequency. The eleven year period manifested by sun-spots is also shown, but to a less marked degree, by the quiescent prominences.

The eruptive type of prominences, on the other hand, is very closely associated with sun-spots. They are rarely found beyond the limits of the sun-spot zones, and they follow almost exactly the periodic frequency of sun-spots. They contain not only the hydrogen, helium, and calcium of the quiescent type, but also iron, magnesium, titanium, barium, sodium, and many other substances, chiefly metals. The eruptive prominences appear as jets, rockets, fountains, etc. They are generally very bright and very active, sometimes undergoing complete transformations in a few minutes.

In 1891 dawned a new era in the study of prominences, when Professor Hale discovered a method of photographing them.

As in the case of visual observations, a spectroscope is used for this purpose, but when adapted to this special work it has been called by Professor Hale a spectroheliograph. It differs from an ordinary spectroscope by having a slit in the focus of the camera, in addition to the ordinary slit in the focus of the collimator. The function of the second slit is to isolate any particular line of the spectrum, and enable the observer to make a photograph in the light of a single element. Thus since prominences are composed chiefly of calcium, hydrogen and helium, it is possible to make a photograph of them in the light of any one of these elements. The H and K lines of calcium and the C line of hydrogen are best adapted to this purpose. The process consists of moving the image of the sun over the first slit, and at the same time, and at the same rate, moving the photographic plate across the second slit. The same result may be accomplished by keeping the image of the sun and the plate fixed and moving the slits. When photographing the prominences, a metal disc is so placed as to cut off all light of the sun except that which comes from the very edge. By removing this disc and making a shorter exposure, a photograph of the sun itself may be made in the light of the same element.

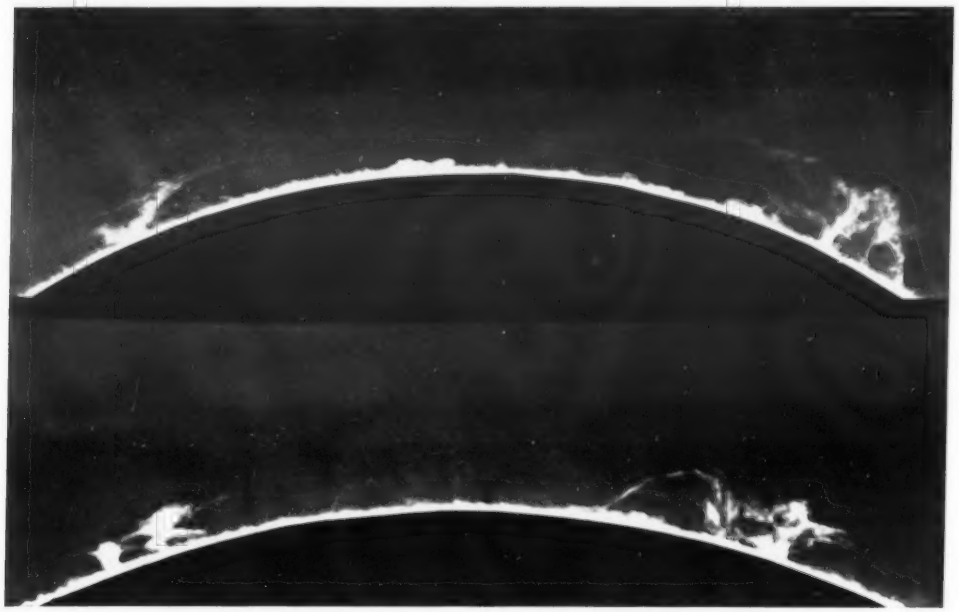
The accompanying plates are reproductions of typical photographs of prominences made by the writer with the Rumford Spectroheliograph of the Yerkes Observatory.

DESCRIPTION OF PLATES.

Figures 1 and 2 of Plate XV represent typical conditions upon the sun's limb as photographed in the light of calcium with the spectroheliograph. Much of the detail is lost in the reproduction. This is true not only of the structure of the prominences themselves but also of the outline of the chromosphere. On the original negatives the chromosphere resembles innumerable tiny thread-like jets. They are not uniform in height like a field of grain, nor do they show any common tendency of inclination. Rising from this irregular surface are forms not unlike low bushes on a grassy hillside. These undoubtedly are small prominences. In fact there seems to be no break from the smallest elevation above the chromosphere to the highest prominence. All seem to belong to the chromosphere as "essentially as mounting waves and tossed spray do to the ocean."

Fig. 1, Plate XV shows a portion of the east limb of the sun, extending from latitude $+32°$, on the right, to latitude $-18°$, on the left. The large quiescent prominence on the right is 1¼

PLATE XV.



CALCIUM SPECTROHELIOGRAMS OF SOLAR PROMINENCES.

Fig. 1. June 20, 1911, $2^h\ 20^m$ G. M. T. Scale: 1mm = 4650 km.
Fig. 2. April 20, 1911, $8^h\ 8^m$ G. M. T. Scale: 1mm = 5550 km.

minutes of arc, or 34,000 miles, in height. The two intensely bright prominences on the left remained quiescent throughout the day, but they are of the type that frequently become suddenly active, culminating in an explosion and annihilation. Near the center of Fig. 1 an eruptive jet can be faintly seen.

Fig. 2 bears a striking resemblance to Fig. 1. The arc in the picture extends from latitude + 28° to latitude — 36°, on the sun's east limb. The big prominences on the right in each picture are of the same type and rather strangely in the same latitude, extending from + 20° to + 25°, but they differ by 85° in longitude.

The prominence on the left of Fig. 2 is of especial interest, since it is connected with an active group of sun-spots, Greenwich No. 6942. The long streamer curving to the right can be traced on the original negative right down into the chromosphere in the region of the spot group. This tendency for sun-spots, or the regions of sun-spot activity, to attract matter from neighboring prominences has been frequently noted, and knots of prominence matter have been observed to descend into such regions with accelerated velocities, running up to about seventy miles a second.

The sun-spots with which this prominence was associated is shown in Plate XVI. The picture was taken on April 26, after the rotation of the sun had brought the group into good view, nearer the center of the disc. Just as in the case of the prominences, this photograph was made with the spectroheliograph using the H line of calcium. The sun-spots are shown surrounded by irregular clouds of glowing calcium vapor. Near the largest spot and between the two main spots may be seen several very bright formations resembling tiny white worms. These are undoubtedly eruptive prominences seen in projection against the disc. One seems to rise from the edge of the penumbra and arch over, and perhaps descend into, the umbra of the main spot.

Plate XIV, (Frontispiece) shows the the type of striking change that is frequently observed in prominences. Fifteen photographs of this prominence were made between 9 A.M. and 4 P.M. The prominence extended from latitude — 45° to latitude — 54°, on the east limb. Between 9 A.M. and noon there was scarcely any change. The prominence remained about 2¼ minutes of arc, or 61,000 miles, in height and presented the appearance shown in Fig. 1, Plate XIV. In structure it possessed two distinct features, a strong column, apparently supported by wide spread legs, and a huge mass resembling feathers.

Shortly after noon the feathery mass began to ascend, and at 1^h 44.8^m P.M., (Fig. 2, Plate XIV) rested upon the column in such a way as to present a fair likeness of a turkey. After 2^h P. M., another complete transformation occurred. Apparently as a result of some internal catastrophe, the bright central part of the prominence was changed into faint cirrus-like clouds, which were being blown away to the east by some lateral current. The extreme length of the prominence at 3^h 38^m P.M., was 6′ or 162,000 miles. Upon the original plates of this prominence velocities ranging from 15 to 20 miles a second have been measured. Such velocities are not an all uncommon.

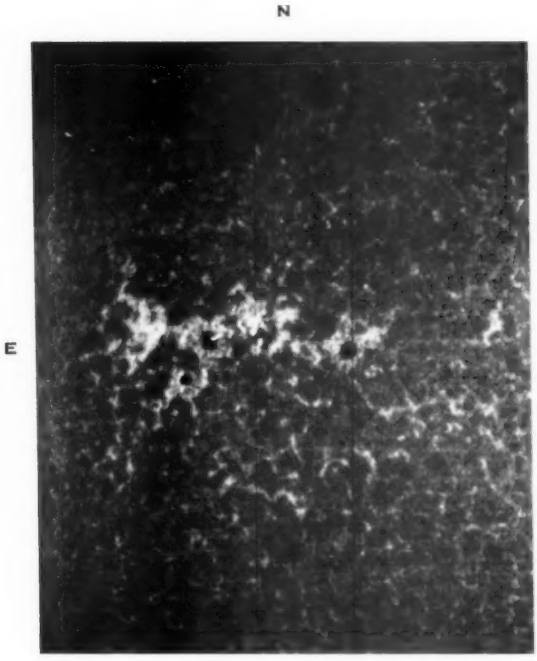
From the plates described it may be seen that, by the use of the spectroheliograph, the distribution and complete delineation of all of the prominences around the sun's limb may be obtained in a few minutes upon a single plate. Successive plates will show the changes in form of the prominences, and, if a sufficient number are taken at short intervals, the complete life history of a prominence may be obtained. By taking simultaneous photographs in the light of the different elements, calcium, hydrogen and helium, and comparing the resulting forms, the way in which these gases are mixed in the prominence may be investigated. Photographs of prominences combined with photographs of the sun's disc enable one to study the relation of prominences to sun-spots, especially their distribution in the region of a sun-spot group and the peculiar manifestations of attraction and repulsion which are frequently noted. These phenomena may also be studied, and in some respects even to better advantage, on high level photographs of the disc, upon which the prominences may be seen in projection, as in Plate XVI, the eruptive prominences appearing bright against the disc, while the quiescent prominences are closely associated with, if not actually identical with, the dark flocculi.

By studying the shapes and bodily motions of the quiescent or cloud-like prominences, some insight may be gained into the general system of vertical and horizontal circulation of the solar atmosphere, that invisible medium in which the prominences float.

These are some of the problems in connection with the sun which are being investigated at the present time. Their complete solution will help to interpret the mystery, not only of the sun itself, but also of that type of stars of which the sun is a representative.

Yerkes Observatory, July 12, 1912.

PLATE XVI.



CALCIUM SPECTROHELIOGRAM OF SUN-SPOT GROUP,
SHOWING ERUPTIVE PROMINENCES.

April 26, 1911, 2^h 23^m G. M. T. Scale: 1mm = 7950 km.

AN ACCOUNT OF THE FOUNDING OF THE CENTRAL OBSERVATORY OF POULKOVA, RUSSIA.

FRANCES MONTGOMERY COWAN.

The following article contains the early history of the Russian Academy of Sciences, and an account of the founding of the Observatory of Poulkova. The material has been taken from the "Description de L'Observatoire Astronomique Central de Poulkova" by F. G. W. Struve who was the first director of the Observatory. The "Description" was published in 1845 at St. Petersburg and is dedicated to His Majesty, The Emperor Nicholas I, founder of the Observatory of Poulkova. In some instances the French of the text has been strictly adhered to, in others, it was necessary to make rather free translations in order to give a general idea of the detailed descriptions of Professor Struve.

Peter the Great of Russia first introduced the study of the sciences into that country. He had a particular taste for astronomy, and had visited the observatories of Greenwich and Copenhagen. Seeing the large amount of scientific work that was being done at these institutions, he determined to establish an Academy of Sciences in Russia which should do similar scientific work and which should serve also to advance the knowledge of the geography of the Russian Empire. In 1724 he founded the Academy of Sciences and at the same time gave to it the first permanent observatory in Russia. This observatory was not in a building entirely by itself, but was situated in the large dome and upper story of the building of the Academy of Sciences, which was considered one of the most magnificent in Europe. This was situated in the heart of St. Petersburg, in a very unfavorable position for making observations, on account of the crowded quarter and the smoky atmosphere. Besides, the walls of the "Hotel d'Academie" were not constructed especially for the observatory, and this rendered its instruments a little unsteady. These instruments were rather crude, though they were the best made at the time. They consisted of a small wall sextant, five feet in length, and a small telescope fixed on a wall and directed on α Lyrae at its passage across the meridian. This was in order to determine the parallax of the star. They also had three smaller telescopes and some minor instruments.

The first director of the observatory was Joseph Nicolas de l'Isle, who was called from Paris in 1726 and who accomplished a great deal of work during his period of directorship, which terminated in 1747. The next director was A. N. Grischow from Germany, at whose instigation two meridian instruments of the greatest possible perfection were bought. He was the first one to conceive the idea that the observatory should be apart from the Academy, and that it should occupy a building of its own, constructed for this purpose and operated in a way similar to the large observatories of Europe. After his death in 1760 a complete set of designs for such a building was found among his papers. However, his dreams were never realized. An accident which brought the idea of the new observatory a little nearer occurred when the King of England, George III, in 1796 presented to the Empress Catherine of Russia a Herschel telescope of six feet focus. M. Roumousky, who was then director of the observatory, was called upon to show her the moon and some star clusters with this instrument. Making use of this opportunity he presented to the Empress his idea of the needs of a new observatory, but apparently she did not interest herself in this to any great extent, as nothing ever resulted from it. During this time, however, the observatory was doing much exact work in determining numerous geographical positions, which should furnish the basis for a general survey of the vast Russian Empire. This had been the principal object of the Academy since its birth, and had been largely accomplished by expeditions which were sent out into various parts of the domain. They carried large, cumbersome instruments and traveled very slowly, which facts made the determination of the positions extend over a long space of time. By 1815 the latitudes and longitudes of all the important points in European Russia were known, and in 1832 all the points in Siberia had been accurately obtained.

After the introduction of the instruments of Troughton, Reichenbach, Fraunhofer and Repsold, the whole character of astronomical observations was changed. The Observatory of Greenwich had possessed instruments made by Troughton since 1814. Germany had regained her former glory by building the observatories of Seeburg, Königsberg, Göttingen, Bogenhausen and Altona. The Russian Academy then felt that a new observatory was necessary to maintain its good work, and to sustain the honor of the first scientific establishment of the empire and the dignity of its illustrious founder, Peter the Great.

This, then, was the motive which impelled the Academy to found a new observatory of its own. M. Parrot, professor of physics at the University of Dorpat, who had had practical experience in the construction of the movable tower at Dorpat, was occupied with the designs for the building. Le Comte A. Kouchelev-Besboradko gave them a piece of ground for its erection near the quarter of Viborg to the northwest of the Capital, which was very favorably situated on account of the open horizon in all directions. In 1830 M. Parrot returned from a scientific trip to foreign countries and was permitted to show his plans to the Czar Nicholas I. When his Majesty was informed of the condition of the observatory and was brought to understand its insufficiency for accurate observations and general scientific work, he decreed that a new observatory should be built near the capital, which should have an equipment well adapted to advance the study of the science to the utmost. It should be erected on the little hill of Poulkova to the south of the city which was a better situation for it than the ground of M. le Comte's gift. In 1833 formal orders were issued for the foundation of the observatory in accordance with the plans of the Academy, and on October 28, 1833 the Emperor gave the order for one hundred thousand roubles to be used for the building. A commission was formed of four members of the Academy, over which M. l'Amiral Grieg, an honorary member, was appointed presiding officer, to carry out the wishes of his Majesty. In addition, M. Bruloff was charged with the architectural side of the work, and M. Dondoukoff-Korsakoff with the administration. M. Grieg was responsible for all the scientific requirements.

The Emperor issued orders for all the peasants who lived within thirty *dessiantines* of the property which had been granted to the Academy to remove their habitations to equivalent ground which had been assigned to them, and an indemnity of forty thousand roubles was given them. A decree was issued that no building could be erected within the distance of a verste, or a mile and a half, from the observatory, without the consent of the director. The plans of the architect for the new observatory were put into the hands of the Emperor. Ground was broken March 1834, and the observatory was completed in 1839. F. G. W. Struve was invited to become the director of the new establishment.

While the observatory was being built, Struve was journeying in Europe, consulting instrument makers, mathematicians

and astronomers. He saw Bessel, Encke, Humboldt, Steinheil and others, and laid before each of them a general plan of the observatory, receiving great encouragement from all. The designs for the new instruments wich he obtained from them were presented to the Academy and accepted. On account of the large dimensions, the superior quality of the instruments and various new accessories not included in the original plan, a larger sum of money was needed than was at first appropriated. This added expense was kindly taken up by the Emperor and the amount of his donation increased to two hundred and seventy thousand roubles, with the additional gift of ten thousand roubles for the foundation of a library.

In 1835 M. Bruloff presented the final plans for the construction of the observatory, and in June of that year the corner stone was laid amidst great celebrations. A medallion with the picture of the Emperor and a picture of the observatory was sealed up beneath the corner stone, with a tablet which bore the following inscription: "In accordance with the order of his Majesty, the Emperor Nicholas Pavlovitch, issued to the Minister of Public Instruction and to the President of the Academy of Sciences, on October 28, 1833, there has been laid on the 21st of June, 1835, the corner stone of the Central Observatory of the Academy of Sciences of St. Petersburg. The construction of this observatory has been carried on under the direction of a commission presided over by the honorary member of the Academy, Amiral Alexis Samoïlovitch Grieg, and composed of the Academicians, Wisniewsky, Struve, Fuss, Parrot and Lenz, and according to the plans of the professor of architecture, Alexander Bruloff."

Commencing in January 1839, an annual allowance of twenty thousand roubles for the running expenses of the observatory was given by Nicholas. This allotment of money was a most important event in the early history of the observatory, since it guaranteed the continuance of the work. In August of this same year, Struve made a second journey to examine the completed instruments and indicate any necessary changes. The instruments were all tested, and as no changes were found necessary they were ordered to be shipped. Eighty-five cases from Munich were forwarded in specially constructed cars. Those from England were shipped by boat to Alexandria and thence taken by the Neva and canals to Poulkova. The one hundred and two cases from Hamburg were transported as far as Lübeck on wagons, their maker, M. G. Repsold, escorting them part way on horseback. From Lübeck they were carried by steamer.

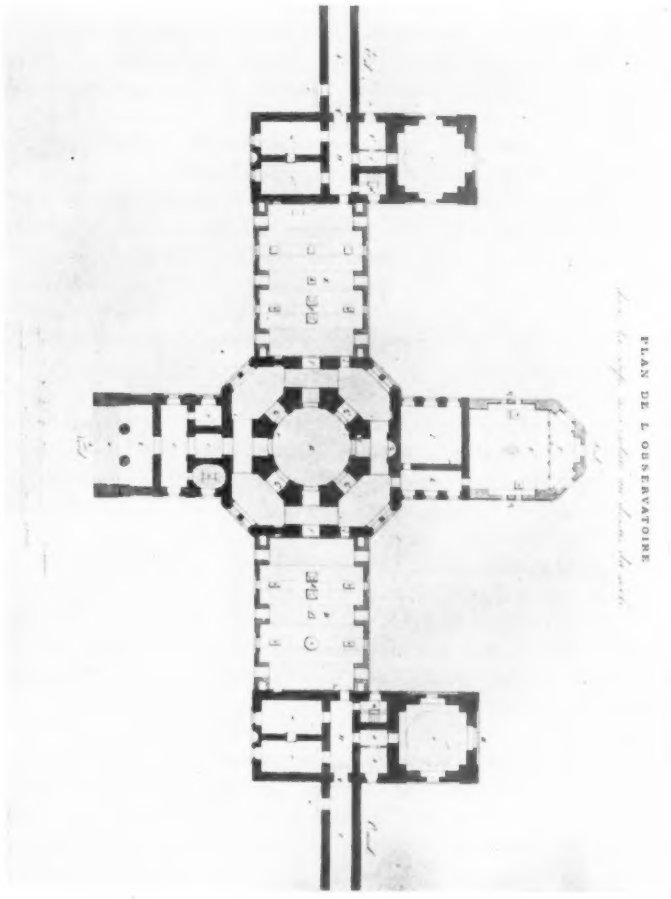
THE IMPERIAL OBSERVATORY OF RUSSIA—DR. O. BACKLUND, Director
Founded by the Emperor Nicholas the First in 1838 at Pulkowa, near St. Petersburg)

A great celebration was arranged for the day of the opening, August 7, 1839, which was attended by all the Russian astronomers, the Academy *en masse*, foreign embassadors, the nobility, the Grand Duchess Olga, and the Empress herself. The Emperor came later, and presented to Grieg a box decorated with his picture, enriched with diamonds. To the Prince Dondoukoff-Korsakoff he gave the decoration of the order of Saint Anne, and to Struve the order of Saint Stanislas, with 11,000 roubles.

The Observatory itself stands on the hill of Poulkova, which is about eleven and one half miles from the outskirts of St. Petersburg. A beautiful highway runs out from the city and winds gradually up the hill to the observatory. The slopes of the hill are covered with a great deal of verdure, and fountains of pure spring water border the walks. The observatory properly called is composed of the large observatory building and four small detached observatories. The large building is 230 feet long, with wings 172 feet long at either end. Corridors connect the wings with the main part, so the astronomers suffer no inconvenience in the severe weather in going from their apartments, which are in the wings, to the main part of the building. The central room of the observatory, Room G in the diagram, is in the form of an octagon with eight pillars in it, which serve as supports for the large movable tower which is directly over this room. The room itself is divided into eight parts by the pillars, with a gallery extending around the outside. At the end of the room, opposite the entrance, stands a bust of the Emperor Nicholas. The room is decorated with portraits of distinguished astronomers and the manufacturers who furnished the instruments.

The room to the west of the central octagon, Room D in the diagram, contains a meridian telescope, a clock and four collimators. This room also contains a large vertical circle by Ertel, which was used by M. Peters for a long series of observations. These include 1) observations of Polaris, 2) observations for parallax and aberration, using seven specially selected stars, 3) observations of circumpolar stars, from 35 degrees to 90 degrees north declination, in order to determine the latitude and refraction, 4) observations of stars from first to fourth magnitude in the zone 15 degrees south to 35 degrees north declination, 5) observations of the sun, moon and planets.

The East Room, Room E in the diagram, contains the large meridian circle of Repsold, a clock and two collimators. This



PLAN OF THE OBSERVATORY.

instrument was used extensively by Sabler in constructing a provisional catalog of 3649 stars, many of which were in Bradley's catalog of 1755. His object was to determine the proper motions by comparing the positions of stars separated thus by an interval of nearly 90 years.

The room to the south, lettered F in the diagram, contains a prime vertical instrument, which was in charge of the director himself. With it he made observations of certain stars for the purpose of determining aberration and the constant of nutation. Later he planned to make a series of observations on zenith stars in order to determine their parallaxes.

The large 15-inch telescope of Merz and Mahler was placed in the central tower. This tower, which is used in place of a dome, was just above the large central room and was very steady, as it rested on the outer walls of the room and received additional support from the eight pillars which have been described before. The tower is 37 feet high and 32 feet in diameter and, with the two smaller ones which are at the two extremities of the building, was built at the shop of M. Thibaut, a noted maker of theatrical appliances. They were covered inside and out with seasoned wood, and had two slits which opened by means of traps, operated by pulleys. The whole tower is placed upon a set of tracks so that it can be turned very easily.

Inside the dome there is a gallery with stairs leading up to it which the astronomers can use in observing with the large telescope. It is also provided with a movable stairway or "tribunal", which takes the place of the usual observing chair. This large telescope has been used 1) for making a catalogue of the northern hemisphere which contains the approximate positions of all the stars from the first to the seventh magnitudes—several astronomers coöperate in this work under the direction of Otto Struve, 2) by M. Otto Struve for making micrometer measures of double and multiple stars, 3) for making observations of nebulae, 4) for making observations of comets.

The personnel of the observatory consisted of the director and chief astronomer, Frederick George William Struve and the assistant astronomers, George Fuss, George Sabler, Otto Struve and C. A. F. Peters, the latter two particularly distinguished for their determination of the constants of precession and nutation. Besides the astronomers, there were the mechanics

and other employees of the Observatory, and the employees of the state, and their families, making altogether 103 persons living on the observatory grounds.

The plan of work included three divisions:

1. Astronomical observations made at the observatory,
2. Geodetic observations in the field,
3. Auxilliary observations, more or less in direct relation to the first two divisions.

In laying out a definite plan for their astronomical researches, Struve was influenced by the subjects of investigation at other observatories. In the majority of astronomical establishments of the time, the observation of the bodies in the solar system formed the principal object of their activity, while the observation of the fixed stars had not yet come to be regarded as important, except as the stars offered points of comparison for determining the positions of the planets. The work of Bradley, the two Herschels and Bessel, indicated that there were great possibilities in this direction. But Stellar astronomy can not be developed without powerful optical means. The large instruments in the equipment of the Observatory of Poulkova promised distinguished success in this line, and hence it was decided that their principal object should be to work for the advancement of Stellar Astronomy. The special lines of research are given below in a much abbreviated form.

1. The determination of the constants of aberration and nutation.
2. Observations for forming a table of refractions.
3. Formation of a catalogue of declinations of circumpolar stars.
4. 5. Observations of the sun to determine the position of the ecliptic.
6. Formation of stellar catalogues.
7. Special observations including double stars, parallaxes, proper motions, variations in brightness, and nebulae.

Their plan included also extensive observations of the members of the solar system.

The adoption of such an ambitious and comprehensive plan was eminently in keeping with the elaborate care bestowed upon the building and equipment of the observatory. The astronomical world has long known how excellently well it was being carried out.

Vassar College.

ON SOME EDUCATIONAL STELLAR PHOTOGRAPHY.

CHARLES BURCKHALTER.

Many years ago, when Professor Barnard began his famous photographic work at the Lick Observatory, he gave me some lantern slides of the Milky Way for class use. They were, of course, very fine but I always felt that they were not appreciated as they deserved to be. The first one shown would create surprise and interest, but all those following seemed to "look alike" to the average person. After cogitating the matter, I concluded that this lack of appreciation was because the views appeared so very different from any thing seen either with the telescope or naked eye. I suggested to Barnard that, by placing a photographic lens out of focus far enough to enlarge the star images to disks that could be easily seen on the screen, and, by exposing only long enough to show the naked eye stars, a picture of well-known groups or constellations would appear somewhat as they do in the sky. He thought the idea a good one, and in his earnest enthusiastic way urged me to try it.

This work would require a short focus lens of good optical quality and, in the next two years, as time and opportunity offered, I tried about half a dozen wide angle lenses and in after years as many more, but they were all deficient, optically, and totally unfit for the work. The most charitable thing I could say of these was that they were all poor but some were worse than others.

I had quite given up the idea when, a year ago, a friend induced me to make one more trial with a Goerz lens. I selected from stock, the one listed in his catalog as No. 1, Dagor, having a focus of six inches. I had little faith in the high optical qualities claimed—when applied to astronomical work—but made a rough camera with fine focussing arrangement, (I had, from much practice, become quite expert at this) and gave it a rough trial. It gave very even trails over a large region. The Big Dipper was the largest group I had ever had in mind, but this little lens would cover a field including both dippers, with room to spare, and with good images over a large area of the plate!

I now made a substantial camera, with exposing cap inside the box, operated from the eye end of the telescope. The focus-

PLATE XVII.

THE LITTLE DIPPER (URSA MINOR)

Photographed by Charles Burckhalter with a Goerz lens.

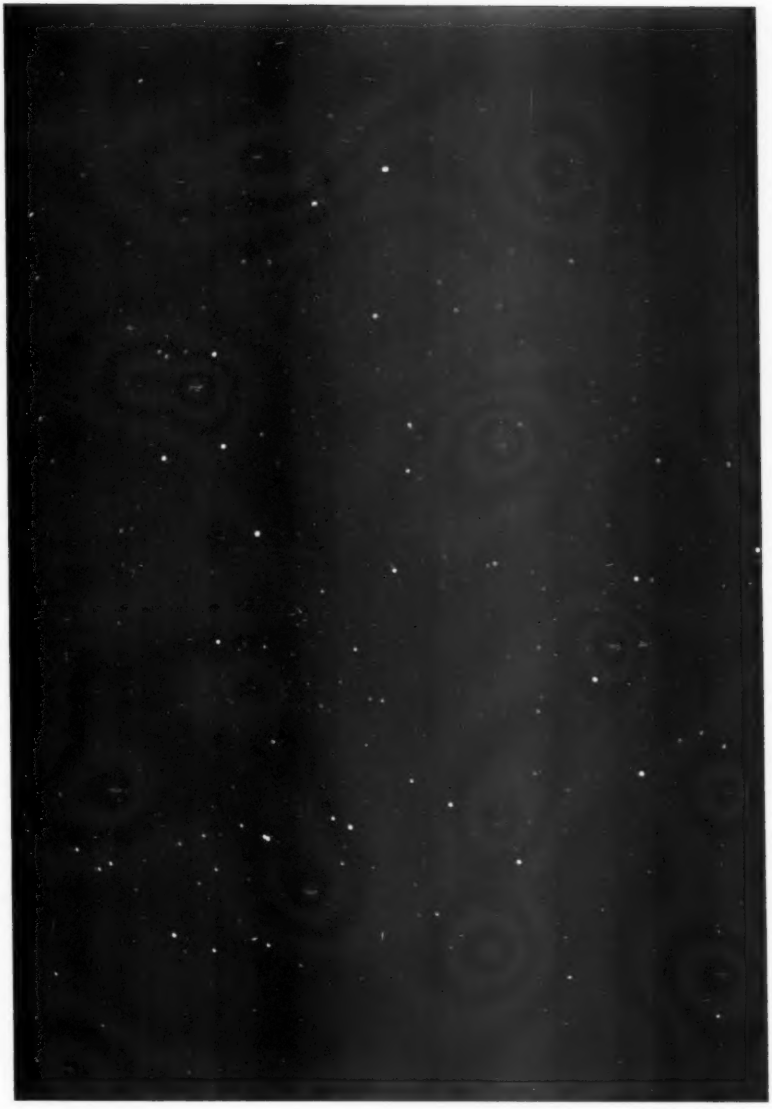
PLATE XVIII.

THE BIG DIPPER (URSA MAJOR)

Photographed by Charles Burckhalter with a Goerz lens.

POPULAR ASTRONOMY, No. 197.

PLATE XIX.



URSA MINOR AND URSA MAJOR

Photographed by Charles Burckhalter with a Goerz lens.

POPULAR ASTRONOMY, No. 197.

ing is done by securing the lens to two inches of brass tube, with outside thread, twenty-four threads to the inch; this screws into a similar tube, which is a part of the flange that is attached on the camera front. By giving the lens and sleeve a turn, or part of a turn, any degree of change can be given and any refinement of focus is possible. The star images, in the accompanying figures, are from four to eight turns from true focus, being out, or from, the plate. The plates were Seed 27, size 5x7.

The exposure time of the Big Dipper was 20^m. Too long an exposure will give the star Delta an image as large and bright as the others, so that it will not give the best nor correct results. The faintest stars that can be easily seen under good conditions require from 50^m to $1^h\ 20^m$, depending upon the color of the star, or, what amounts to the same thing, its photographic magnitude.

I found myself in trouble at once. How large should the star disks on the negative be to make the most effective lantern slide? Where should the line be drawn as to which stars should be included, or left out, those easily seen by ordinary eyes, or those seen only by the sharpest eyes under the most favorable conditions? These and others, however, are questions of personal judgment, or taste, and one can suit himself, but how to get stars of low photographic intensity to appear with something like their visual brightness, and the still more difficult problem of keeping down the stars visually faint but photographically active, has not been solved by ordinary plates. Whether it can be done by color plates (which I have not tried) will be tried next winter.

As time and state of the sky permitted, I made a number of exposures last winter, and give here some of the best results I have, so far, been able to obtain, with the understanding that they are to be regarded as of only educational value; in fact I think of them only from a class-room standpoint.

The work was done under trying conditions. The observatory is only thirtysix feet above sea level, located on the shore of San Francisco Bay, five miles to the leeward of a great city, and in a city of over two hundred thousand population, within a thousand feet of its two principal business streets, with their thousands of electric lights and several sky-scrapers beaming down upon me. The building is set in a two acre public park with eleven two hundred candle power electroliers within a radius of one hundred feet and three street arc lights within two

hundred feet, three electric car lines from one to three blocks distant with cars and trains flashing along every few minutes—one line using a twelve hundred volt current,—with visitors and schools every clear evening. It may seem that conditions, as a friend remarked, "could be worse but not much."

There are, however, many things to be thankful for. The city officials are kind to me, requiring the park and street lights to be "installed to his satisfaction," so the wires were brought into the equatorial room, where I can cut off the lights that are at the time the greatest offenders. The neighbors, also, are kind, never complaining about the lights being put out. The visitors and schools leave early, the sky-scrapers and electric cars are out of business by two o'clock, as are also most of the lights on the business streets, and then, if the sky permits, I can make exposures of an hour or more in any direction without fogging the plate, and down to forty degrees from the horizon!

During the winter season we usually have from ten to twenty days of dry north winds, greatly dreaded by the farmers, but the sky is then beautifully clear, so that exposures of three hours, or perhaps more, and down to thirty degrees from the horizon can be made. "Its an ill wind" etc. No photographic work can be done satisfactorily between March and September.

A brief description of the plates is all that seems necessary:

Plate XVII. The Little Dipper. The exposure was sufficient to bring out many stars not visible to the naked eye, and not wanted, but the stars Epsilon and Eta are so weak in actinic rays that the long exposure was necessary to bring them out strong enough for printing. The exposure was 1^h 20^m with stop F4.

Plate XVIII. The Big Dipper. Very easy. Twenty minutes is ample exposure and leaves the plate without small stars, and clear, giving the black sky, so desirable.

Plate XIX. Both Dippers on the same plate with the same difficulties as Plate XVII; plate was slightly fogged by the city lights.

Plate XX. Orion. It is difficult to draw the line where exposure and development should stop. Betelgeuse is only 2.52 magnitude, photographically, according to Harvard, while visually it is brighter than first. To show it as first magnitude on the plate is not easy. I do not wish to suggest it, but I sometimes believe that different results are obtained on different nights on red stars, other things being equal. Kappa, while only second magnitude visually, is nearly equal to Rigel on the plate.

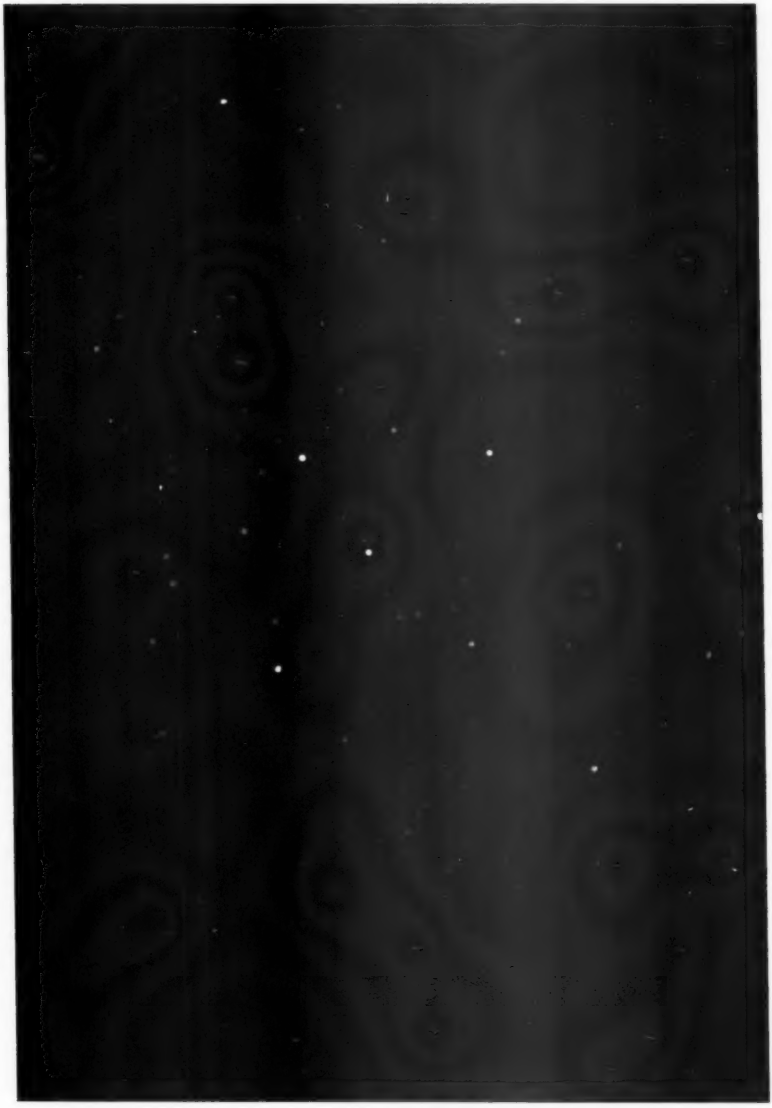
PLATE XX.

ORION

Photographed by Charles Burckhalter with a Goerz lens.

POPULAR ASTRONOMY, No. 197.

PLATE XXI.



CYGNUS

Photographed by Charles Burckhalter with a Goerz lens.

PLATE XXII.

SIRIUS, ORION AND THE PLEIADES

Photographed by Charles Burckhalter with a Goerz lens.

POPULAR ASTRONOMY, No. 197.

PLATE XXIII.

POLAR STAR TRAILS

Photographed by Charles Burckhalter with a Goerz lens.

POPULAR ASTRONOMY, No. 197.

Plate XXI. Cygnus. The Cross of course is the object sought. With ordinary plates Eta is no brighter than some near neighbors, while Beta is more than a magnitude fainter photographically than it is visually. Harvard gives 4.13 and 3.10. Delta is also weak on the plate. I made many failures on account of the faintness of these stars. One of the reasons, as I now know, was that the images were too large, but it was too late in the season to remedy. I took a negative to a photographic studio and had a young lady strengthen these images, very materially improving the view; but the fact that it has been retouched in the case of β, δ and η should be remembered.

Plate XXII. With Sirius and the Pleiades on a 5x7 plate the great angle of the lens is shown. The lens was working with stop F 4 over 2,800 degrees, or about one fifteenth of all the sky, on the plate! Refraction in such a wide field is an unsurmountable difficulty, because of the great difference in altitude and change of position during the 1^h 10^m exposure. It has some value as a star map of that part of the sky.

Plate XXIII. Polar trails. First an exposure of 30^m was given, then the driving clock was stopped and the stars were allowed to trail for three hours, excepting two intervals of 5^m each, which breaks the trails into intervals of an hour. I hope to have a night clear enough to make an exposure of six hours in length, with hourly or possibly more frequent breaks. A number of stars are shown that were not bright enough to leave conspicuous trails.

These trails, which are from the two dippers and adjacent stars, appear in something like a tangle; with pen and ink I spotted the dipper stars, on the back of the plate, for a lantern slide. It is most spectacular, but brings sudden order from apparent chaos.

The work was new and full of difficulties, but I believe I now have the necessary skill and judgment to make a greater success of it. I expect, the coming winter, to do it all over again, with a new camera, holding 6½x8½ plates, stopping down to F8, or F16 for large areas with bright stars, using photographic plates sensitive to light of different wave lengths. I hope to greatly improve upon anything I have so far accomplished, and, if the EDITOR thinks it worth while, I will be glad to report results to the readers of POPULAR ASTRONOMY.

Chabot Observatory,
Oakland, Cal., May, 1912.

MAGNITUDE ESTIMATES OF NOVA GEMINORUM No. 2.

JOEL STEBBINS.

The determination of the light changes of a new star presents a unique problem in stellar photometry. The rapid variations which usually follow the first outburst can not be determined by a single observer, nor even by many observers unless they are widely distributed in longitude. Although measures with some form of photometer are preferable, the ordinary estimates according to Argelander's method are of real value if each observer will publish the individual comparisons, so that some one may reduce all of the results to a common system. At present this method seems to be the only feasible one in the case of a Nova, for there are not enough observers who can and will make photometric measures of such a star. It therefore seems the duty of each astronomer to publish his estimates, no matter how fragmentary they are, since it is only by such coöperation that a good light-curve can be derived for the first few weeks of the history of a Nova. When the star has settled down to gradual changes, many observations are not needed.

After the appearance of Nova Geminorum last March, I estimated its brightness on different nights during two months without devoting any special attention to this object. The observations were made in the free intervals of other work, and as this was the only star which I was following, the estimates were laid aside when made, and finally reduced all at once. The comparison stars and their adopted magnitudes are as follows, H. R. referring to Vol. 50 of the Harvard Annals.

Comparison Stars.

Star	Letter	Mag.	Name
H.R. 2697	τ	4.48	τ Geminorum
2398	*a*	5.05	49 Aurigae
2793	*b*	5.21	65 Aurigae
2480	*c*	5.54	28 Geminorum
2512	*d*	5.76	
2738	*d'*	5.87	53 Geminorum
2643	*e*	5.95	
2586	*f*	6.01	
2620	*g*	6.46	
B.D. + 32°, 1433	*h*	7.0	
B.D. + 32°, 1437	*i*	8.0	

It happened that several of my early comparisons were with the star 48 Aurigae, which was not marked as a variable on the chart which I used. This caused some confusion for a time, but I finally made a note that "48 is certainly variable", and on looking it up found, of course, that this is the short period variable RT Aurigae. The comparisons with this star were therefore rejected.

The table of observations contains the date, Greenwich Mean Time, comparisons, and adopted magnitudes. The instrument was a 6 power prism binocular, except for the last two dates when a 3-inch finder, power 25, was used. The value derived for 1 "grade" is 0.08 mag.

OBSERVATIONS OF NOVA GEMINORUM NO. 2.

Date 1912	G.M.T. h	m	Comparison	Mag.	Remarks
March 15	13	05	τ 5 *N*	4.9	
17	15	50	*a* 3 *N* 3 *c*	5.3	
18	14	00	*a* 4 *N* 4 *c*	5.3	
19	13	35	*a* 2 *N*	5.2	
19	13	35	$N = b$	5.2	
22	14	20	τ 5 *N* 3 *a*	4.8	
24	14	25	τ 2 *N* 4 *a*	4.7	
25	16	50	τ 5 *N* 7 *d*	5.0	Moon
26	14	15	$N = d$	5.8	Moon
30	14	10	$N = d'$	5.9	
April 2	15	05	*c* 3 *N* 3 *d*	5.6	
3	15	07	$N = d$	5.8	
3	15	07	*c* 5 *N* 3 *e*	5.8	
5	14	45	*d* 2 *N* 2 *e*	5.9	
7	14	20	*f* 2 *N* 2 *g*	6.2	
8	14	40	$N = g$	6.5	
10	14	05	*f* 3 *N* 3 *g*	6.2	
14	15	25	*g* 2 *N* 3 *h*	6.7	
15	14	00	*g* 3 *N* 3 h	6.7	
18	14	40	*f* 5 *N* 3 *g*	6.3	
22	15	0	*g* 4 *N* 3 *h*	6.8	Moon
26	15	20	*h* 5 *N* 7 *i*	7.4	Three-inch, Moon.
May 9	15	05	*h* 5 *N* 5 *i*	7.5	Three-inch

University of Illinois Observatory,
Urbana, May 30, 1912.

ALPHA AQUILÆ.

Whilst azure Vega sparkles overhead
And grand Arcturus lights the western sky,
Whilst wierd Antares seeks his southern bed,
And Northern Cross is shining huge and high;
When Leo goes and Virgo reigns instead
And little Libra's rule is drawing nigh,
When northwardly yon Bear has turned his head,
Then, beams the Eagle's bright and blazing eye.

CHARLES NEVERS HOLMES.

Hotel Nottinghan, Boston, Mass.

THE DISTANCES OF THE STARS.

HEBER D. CURTIS

Continued from page 355

Before proceeding farther a point must be explained which will be necessary for some of the conclusions drawn, which, though very elementary from the standpoint of the astronomer, may not be clear to others. Astronomers have a way of estimating the accuracy of a result by what is called its probable error. To illustrate: Suppose you were given the task of measuring the length of a city block with nothing better than an ordinary foot-rule, and to get as accurate a result as possible you repeated the measure twenty-five times. It would be found that no two of the measures would agree, but that some would be several inches larger or smaller than the general average of all twenty-five measures. This average of the measures would be the most probable value of the length of the block, and from the deviations of all the separate measures from this average value the surveyor would calculate a quantity which he calls the probable error of the result. This probable error is, to a great extent, a measure of the accuracy of the work; manifestly the probable error of one hundred such separate measures would be smaller than the probable error of only five measures, and the probable error of twenty-five carefully made measures smaller than that from twenty-five carelessly made measures. The probable error, then, is a measure of the accuracy of a result as far as mere accidental errors are concerned; but a point must be emphasized here, as it has at times been overlooked, even by men of considerable experience. While the probable error takes account of the *accidental* errors of measurement, and to that extent is a measure of the accuracy of a result, it entirely fails to indicate the inaccuracy of a result in so far as that result is affected by *constant* errors —that is, those errors which come from permanent faults in the instrument or in the methods of making the observations. To return to the former illustration, suppose that the foot-rule used was only one one-hundredth of an inch too long; then from this *constant* error the side of the block would come out six or eight inches too short, even though the probable error calculated from twenty-five measures gave reason to suppose that it was a much more accurate value than this. It

is generally estimated that the *actual* error of a result may be, because of *unknown* constant errors, three to five times the size of the calculated probable errors. The actual uncertainty, then, in the determination of the distances of the stars is certainly larger than the computed probable errors.

DISTANCES OF *Sirius* AS DETERMINED BY VARIOUS OBSERVERS.

Distance Light-Years	Probable Error Light-Years	Instrument	Observer
9.6	±3	Meridian circle	Henderson
17.3	±9	" "	Maclear
7.6	±2	" "	Belopolsky
9.6	±1	" "	Flint
8.8	±0.2	Heliometer	Gill and Elkin
8.0	±0.3	"	Gill and Elkin
8.8	±0.2	"	Gill

The above table gives an example of a fairly well determined distance, as the different values are in quite good agreement, and from the size of the probable errors it will be seen that, though the uncertainty of the results is really to be measured by trillions of miles, still we have a very fair idea of the approximate distance of this star. A less favorable result is shown from a tabulation of some of the different values for the distance of 1830 *Groombridge*:—

DISTANCES OF 1830 GROOMBRIDGE AS DETERMINED BY VARIOUS OBSERVERS.

Distance Light-Years	Probable Error Light-Years	Instrument	Observer
14.2	± 8	Meridian circle	Peters, 1842
18.1	± 2	Heliometer	Schlüter, 1842
95.9	± 75	Micrometer	Struve, 1848
98.8	± 75	Heliometer	Johnson, 1852
142.0	±203	"	Johnson's results as revised by Auwers
36.6	± 10	Micrometer	Brünnow, 1871
40.7	± 12	Meridian circle	Jost, 1890
Negative result		" "	Flint, 1894
32.6	± 10	Photography	Russell, 1910

The more modern results for 1830 *Groombridge* agree fairly well, but even for these it will be seen that the computed probable error of the result indicates an uncertainty in the distance of over ten light-years; in other words, the calculated uncertainty in the distance of this star is over twice the entire distance to our nearest neighbor, *Alpha Centauri*. This point is emphasized without any desire to depreciate the results secured in this field, but simply to make plain, as far as possible, that except for the nearest stars the problem of determining

the distance is almost insoluble by present methods, for it will be at once seen that for the more distant stars the probable error of the result would be greater than the determined parallax. This will be somewhat clearer from the following tabulation:—

AVERAGE PROBABLE ERRORS OF PARALLAX DETERMINATIONS

(Derived from numerous published results by various observers.)

Method.	Average Probable Error.
Meridian circle, micrometer, etc	0.040 seconds of arc
Heliometer	0.035 " " "
Photographic methods	0.026 " " "
Photographic methods (from 26 of the most modern determinations with long-focus instruments, mainly by Schlesinger)	0.014 " " "
The average parallax of all stars to the seventh magnitude is probably not greater than	0.008 " " "

It will be seen that the average parallaxes of even the brighter stars are considerably smaller than the calculated probable error of even the most refined modern photographic methods; it is possible to determine the distances of stars out to about one hundred light-years with some degree of confidence, but beyond this point the inaccuracy of our best methods is equal to or greater than the very quantities we are trying to determine. From the direct methods, then, we have learned only the distances of some of our very nearest neighbors, and valuable as the results are in giving us some idea of the size of the stellar universe, they are in no sense representative of the universe of the stars as a whole. The individual distances of stars farther away from us than one hundred light years must always remain only very imperfectly known, unless more powerful and accurate methods of attacking the problem directly are discovered in the future.

THE TEN NEAREST NEIGHBORS OF THE SUN.

Star	Mag. nitude	Parallax ″	Distance in Light Years	Distance in miles
Alpha Centauri	0.9	0.76	4.3	25 trillion miles.
Lalande 21185	7.5	0 47	6.9	41 " "
61 *Cygni*	6.1	0.41	8.0	47 " "
Sirius	−1.4	0.38	8.6	51 " "
Cordoba Zones 5^{h}.243	8.5	0.32	10.2	60 " "
Tau Ceti	3.7	0.32	10.2	60 " "
Nu^{1} *Draconis*	4.9	0.32	10.2	60 " "
Procyon	0.7	0.30	10.9	63 " "
Lacaille 9352	7.1	0.29	11.1	66 " "
Epsilon Indi	4 8	0.28	11.6	69 " "

Note that in the above table both bright and faint stars occur,—i.e. we cannot assume because a star is faint that it is, because of the fact, exceedingly remote; it is not impossible that other quite faint stars may be found to be relatively close.

Pessimistic as the foregoing summation of three-quarters of a century of effort may seem, it is fortunate that we have another method of determining, not the distance of some particular star, but the average distances of large classes of stars, with considerable accuracy, even though this average distance is so great that even the most modern photographic methods are useless. These results are made possible by the results secured for more than a century by astronomers who have devoted their energies to the determination of the exact positions and the proper motions of the stars, in combination with the most modern results secured by the spectrograph. We may say that to secure these results the oldest astronomy has joined hands with its most modern development, and this newest knowledge, in its most accurate form, is less than one year old. One of the most important links in the chain is that formed by the work of the Lick Observatory during the past fifteen years, for Dr. Campbell and his associates have there secured with the spectrograph the largest collection of determinations of the velocities of the stars in existence.

I will first endeavor to put in popular form some of the principles underlying this indirect method of finding the average distance of the stars. In a sense, the problem goes back to the familiar illustration of the surveyor and his measured base line. As you have seen, the enormous base line made by the earth swinging from one side to the other of its orbit has been found to be all too small. But the spectroscopic results show that the sun, with its attendant retinue of planets, is itself moving through space at the very great velocity of twelve miles in every second of time. From this motion we have, in the course of time, a very much greater base line. A star which would shift its position in the sky only one one-hundredth of a second of arc while the earth moved from one side to the other of its orbit would show a shift of nearly two seconds after one hundred years from the motion of the sun through space, and two seconds of arc is a quantity much easier to determine than one one-hundredth. Similarly, the small proper motions of the stars, imperceptible in a year's time, become noticeable in a century. The element of time now becomes an all-important factor, for several generations

of astronomers have given us the minute changes in position from which we derive the motions of the stars across our line of vision, the so-called proper motions of the stars. By methods into which it is not necessary to enter here, the spectroscope enables us to tell how fast a star is moving in a direction directly toward or directly away from us, known as the velocity in the line of sight, or the radial velocity of a star.

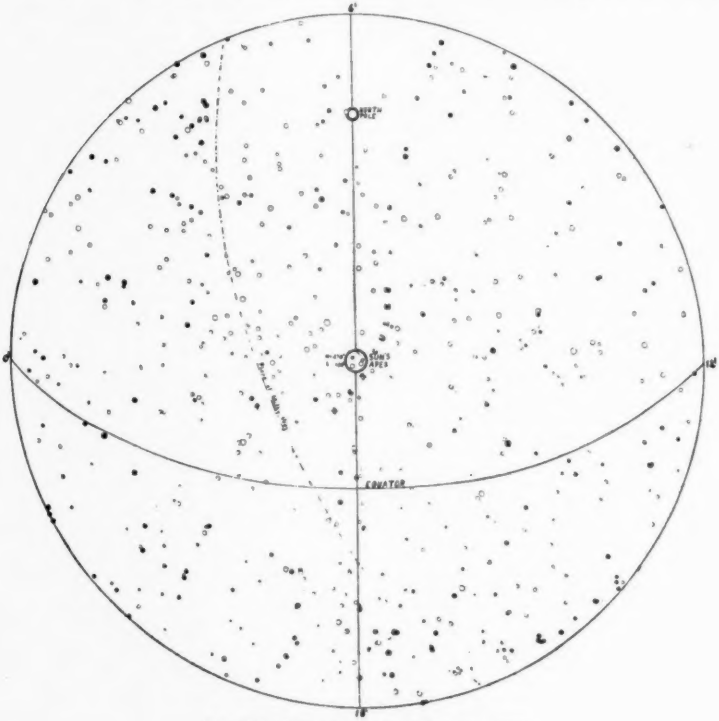


FIG. IV.—VELOCITIES ABOUT SOLAR APEX.

Now it is found that in one part of the sky the stars seem to be coming toward us at an average rate of twelve miles a second, while in the opposite half of the sky they are on the average moving away from us at this rate. The inference is clear that it is our sun which is moving toward the one part of the sky and away from the other at this rate of speed. This can be seen graphically in Figures IV and V. Figure IV represents the brighter stars in that half of the sky surrounding the apex, the point toward which the sun is moving; open

circles represent stars whose radial velocities are such that they appear to be coming toward us, the full black circles stars which are moving away from us apparently. It will be seen at once from Figure IV that nearly all the stars around the apex seem to be coming toward us, while around the edge of the map the open and dark circles are about equally divided. In figure V, which shows the half of the sky around the antapex as a center, it is just as clear that the sun is receding from that part of the sky, for here nearly all the stars are moving away from us. The older astronomy, instead of using the then unknown velocities in the line of sight, made use of the observed proper motions of the stars to determine the point toward which the sun is moving. But the spectroscope has one overwhelming advantage; knowing the distances of so few of the stars, a study of the proper motions will give a pretty good value of the direction the sun is going, but a very

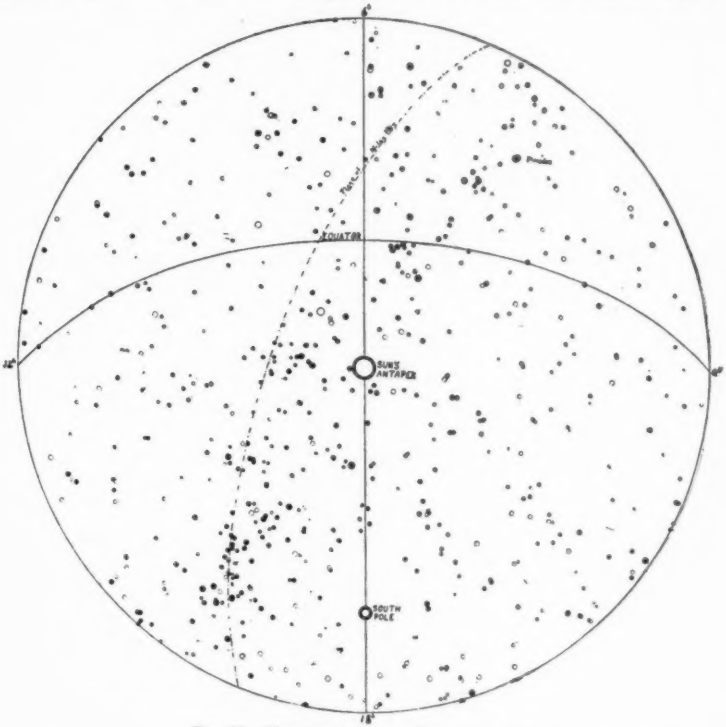


FIG. V.—VELOCITIES ABOUT SOLAR ANTAPEX.

imperfect idea of the rate of its motion, while the velocities determined by the spectroscope are absolutely independent of the distance of the star, so that it not only gives the direction in which the sun is moving through space, but gives also the rate of speed, something which the study of proper motions could do only roughly and with many assumptions as to the distances of the stars involved. The point toward which the sun is moving is in the constellation of *Hercules*, about fifteen degrees southwest of the bright star *Vega*.

Perhaps an elementary illustration at this point will aid in making clearer the means by which the results of proper motion studies and velocities in the line of sight are combined so as to give the average distances of the stars. Imagine ourselves on a very large level plain, and all around at a great distance a large number of objects too far away to be observed except through telescopes, and moving at random in all directions over the plain. With our telescopes we could study and tabulate the motions for these moving objects so that we could say, for instance, that these objects were moving, on the average, one degree of arc per hour across the field of view of our telescope. This deduction from the "proper motions" of these bodies would in itself tell us nothing as to the distances of the objects. But now suppose that in some way we could learn that these objects were men, and that they were moving at an actual rate of one mile per hour, on the average, across our field of view, some moving much faster than this, some much more slowly. Then the problem would be comparatively simple, for it would resolve itself into the question: How far away must an object be so that a base line of one mile would look like one degree? The answer would come out that these men must be, on the average, fifty-seven miles from us. Some might be much closer, and some much farther away, but if their average movement across the field of our telescope were one degree per hour, and we could find that their average actual movement in this time and in this direction was one mile, we should know that their average distance was as given above. Now with the stars, several generations of astronomers, patiently accumulating accurate positions with their meridian circles, have ascertained the average motions across the sky of several thousand stars, with a high degree of accuracy. Fifteen years' work, mainly at the Lick Observatory, has now made available through the spectrograph, for over a thousand stars, the fact that the stars have a certain average velocity in miles

per second. For instance, Dr. Campbell found for one hundred and eighty stars resembling our sun in type that their average cross proper motion in the sky from the values derived by Professor Boss was about 0.11 seconds of arc per year, while their average speed toward us, given by line of sight velocities determined with the spectrograph, was 8.9 miles per second, or two hundred and eighty million miles in a year. How far away must a base line of that length be so as to look only 0.11 seconds of arc in size? The answer comes out, in miles, five followed by fourteen ciphers, or over ninety light-years. The problem is much more complicated than in the simple illustration of the distant moving objects on a plain, for the value of the sun's own motion through space must be eliminated from the observed radial velocities of the stars, and that part only of the proper motion used which is not affected by the motion of the sun through space.

Classified with regard to the elements shown by their spectra, it is found that the stars fall into a relatively small number of well-marked spectral types which are designated by letters; it would only confuse here to go into the distinctions between the various types, and it will be sufficient to say that the stellar types lettered O and B are supposed to be young stars, in the earliest stages of their development; those lettered A are still farther along; those lettered F and G are more nearly like our own sun in spectrum and presumably at about the same point in their evolution; while those lettered K and M are on the way to stellar old age and extinction. Now, perhaps, the most remarkable result from the radial velocities is that the average velocities of these different types of stars, when the effect of the solar motion is removed, varies with the type.

STELLAR RADIAL VELOCITIES AS FUNCTIONS OF SPECTRAL TYPES.

Type	No.	Average Radial Velocity
O and B	141	5.5 miles per second
A	133	6.1 " " "
F	159	8.6 " " "
G and K	529	9.4 " " "
M	72	10.3 " " "
Nebulæ (Keeler)	13	14.5 " " "

It will be seen that there is a steady increase in average velocity according to the type of the star's spectrum, and these results open very many interesting questions. Can it be, as Dr. Campbell puts it, that all matter is not equally old from a gravitational standpoint? These results show, moreover, that

to find the average distances of the stars we cannot consider all stars as a whole, but must find their average distances by classes. The next table shows Dr. Campbell's results for the distances of the different types of stars from a comparison of their average cross-motions with their average radial velocities.

AVERAGE DISTANCES OF STARS BY SPECTRAL TYPES.

Type	No.	Average Yearly Cross-motion	Average Radial Velocity per Second	Average Relative Parallax	Average Distance Light-years
B-B5	312	0″.0078	3.9 miles	0″.0061	534
B8-B9	90	.0182	4.2	.0129	253
A	172	.0368	6.5	.0166	196
F	180	.1075	8.9	.0354	92
G	118	.0748	9.9	.0223	146
K	346	.0516	10.4	.0146	223
M	71	.0384	10.6	.0106	308
	1289				

It will be seen at a glance that the younger B type stars are on the average very far away from our system; these are nearly all situated in or near the Milky Way. On the other hand, the F and G type stars, most like our own sun, are nearest of all to us. It seems as though our sun were one of a great cluster of similar stars fairly near to us as astronomical distances go.

Professor Boss, using the proper motions alone, with the aid of the velocity of the sun in space, secured results very similar to these, though in his results the difference between the various types was less marked, due doubtless to the fact that in his solution he was able to use over four thousand stars, going down nearly a magnitude fainter than the stars used by Dr. Campbell. These two epoch-marking pieces of work, attacking the problem from different standpoints and in a marked degree supplementing each other, appeared almost simultaneously a few months ago, and give us a far more accurate idea of the size of the universe than has hitherto existed. The general results may be shown graphically in Figure VI. Here it will be seen that the average distance of the stars most like our sun in type is roughly one hundred light years, and this circle represents also about the limit of the older methods. Outside of this will come the K and M type stars, and farthest out of all the younger B type stars at the enormous average distance of five hundred light years. These results apply only to the brighter stars; how much farther out the fainter stars may extend we can only guess. The small circle in the center

of the diagram is twenty-four light-years across and would contain the ten nearest neighbors of the sun. Some idea of the scale of the figure may be gathered from the fact that the dots over the letter *i* are two thousand times the distance from one side of *Neptune*'s orbit to the other,—in other words, nearly three million solar systems could be placed in the area of the dot.

If the sun were removed to a distance of thirty light-years, it would be just visible to the naked eye as a sixth-magnitude star, and at the average distance of the B type stars would be visible only in a telescope; in other words, as stars go, it is a rather small and inconspicuous object.

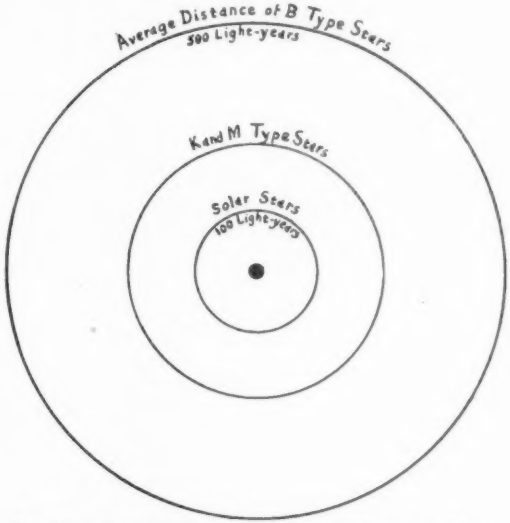


FIG. VI.—AVERAGE DISTANCES OF THE BRIGHTER STARS.

Only less important than the more accurate data so recently obtained as to the size of the stellar universe are the remarkable facts that the stars of different ages are moving at different average velocities through space. To quote from Dr. Campbell's recent paper:* Why should not the materials composing a nebula or class B star have been acted upon (by gravitation) as long and as effectively as the materials in a class M star? Keeler's observations, it is true, would indicate that the planetary nebulae are traveling at least as rapidly as a well-developed star, but the Great Nebula in *Orion* is radially at

* *Lick Observatory Bulletin* No. 196.

rest with reference to the stellar system, and the latter condition may exist in the other extended nebulosities. The established fact of increasing stellar velocities with increasing age suggests the questions: Are stellar materials in the ante-stellar state subject to Newton's law of gravitation? Do these materials exist in forms so finely divided that repulsion under radiation pressure more or less closely balances gravitational attraction? Does gravitation become effective only after the processes of combination are well under way? Are the high observed velocities of the planetary nebulae due in some or all cases to the gravitational disturbances which accompany a conversion of ordinary stars into planetary nebula; such disturbances in velocity and in physical condition as might transpire through the close approach of two massive bodies'? . . . . The proper motion data do not indicate the presence of a single class B star in a great sphere, concentric with the sun, which must contain hundreds of stars of other spectral classes, A to K, inclusive. We are led to believe that the present class B stars assumed stellar form in regions relatively near to their present positions . . . . The absence of class B stars in our vicinity may indicate primeval vacancy in this region, or the development of stars in this region to an effective age beyond that corresponding to the class B spectrum . . . . It seems not unreasonable to suppose that the large average distances of the class M or red stars are the result of high velocities for long periods of time; and that their nearly uniform distribution over the stellar sphere is due in a large part to the disturbing action of other individual stars through whose spheres of influence they have passed, and in part also to their low radiating efficiency, which renders invisible any red star which may exist in distant regions of the Milky Way."

A reasonable conclusion, in the light of our most recent knowledge, would be that such an object as the wonderful cluster in *Hercules* is probably at least one thousand light-years away. There are many similar clusters in the sky; nearly all lie in or near to the Milky Way, and this is the part of the sky where we find practically all the class B stars, with average distances for the brighter stars of about five hundred light-years. It may be much farther than this from our system, though we have no definite knowledge on this point. Such a cluster would then be at least one light-year across in its densest portion, and the stars which seem so closely packed are really separated by enormous distances. The stars, so close together

in a photograph of this cluster that they appear to touch, must be at the very least thirty billion miles apart, or six times the diameter of the solar system; this, then, may be looked upon as almost a small universe in itself, perhaps containing twenty-five thousand separate suns and with possibilities for unnumbered planets circling about them. Similar dimensions probably obtain for such a great spiral nebula as *Messier* 51, in which we see exemplified the process of evolution of stellar systems from the originally formless diffused nebulosities. The larger nebulæ seem to have drawn into themselves most of the material lying around them, so that they are in regions which are to some extent drained of stars. A casual inspection of photographs of the nebula in *Orion* will show this, and it has been corroborated by actual count and tabulation of the star density around such nebulæ.

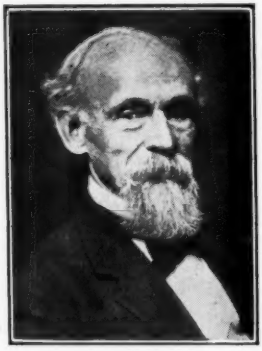
In the clusters and particularly in the spiral nebulæ we see the proofs of the evolutionary process through which matter has gone and is going to form the stars. Is there some greater scheme underlying the whole mighty fabric? Is this inconceivable space filled with millions of mighty suns, clusters and nebulæ arranged on any system? To a certain limited extent we may give an affirmative answer. Perhaps the best proof of this lies in the distribution of the nebulæ. The positions of the clusters and nebulæ in the sky have been plotted by Mr. S. Waters, and it is found that nearly every cluster lies in or near to the Milky Way, while practically all the nebula group themselves as far as possible from the Milky Way. This arrangement cannot be chance, but just what it means we can only guess as yet.

The human mind finds itself placed between two infinities—that of the infinitely small and the infinitely great. From the bulb of one of these incandescent lights the maker has exhausted nearly all the air, yet there remain in it after this process a number of molecules millions of times greater than the total number of stars visible in the mightiest telescope, particles smaller than the resolving power of any microscope, but moving rapidly in their minute paths, a microcosm of the infinitely small, as difficult to conceive of as the cosmos of the infinitely great. Great as is our own sun, we find it difficult to imagine that it is only a very ordinary and inconspicuous unit among hundreds of millions of similar units. That these millions of massive bodies should be traveling through space in all directions at speeds of five to ten miles in every second of time is

likewise difficult to conceive, but more wonderful and difficult of conception than all is the vast realm of space in which they move under the influence of that still unsolved mystery, gravitation,—a space so vast than the distances apart of the separate units are to be measured by trillions and quadrillions of miles, a realm so nearly infinite in extent that it is practically so, as far as our finite-thinking minds can grasp it. Truly a supremely vast and supremely wonderful universe. And what may be still farther out, beyond that part to which our mightiest telescopes can reach? We do not know.

A TRIBUTE TO JOHN A. BRASHEAR.

The following beautiful sonnet was written in honor of one of America's most famous astronomical instrument makers, on the occasion of his seventy-first birthday. Dr. Brashear is not only a maker of astronomical instruments of the highest type, but he is at heart an enthusiastic lover of astronomy and interested in all plans for the advancement of the science. Much of the success of other men has been due to his keen appreciation of their problems and his careful working out of the fine details and extreme precision in the apparatus which they required. He is especially interested in the Allegheny Observatory and twice, in the interim between directors, served efficiently as its temporary head. [*Editor.*]



SON of the Toiling Many, Brother of All Mankind,
Pilgrim of Starry Trails, far traced to the Last Sun's Bound,
Voyager of Sapphire Seas, Sounder of Depths profound,
Meting the Pregnant void, reck'ning the Bonds that bind
Planet and Asteroid, with Golden Measures of Mind;
Heart of a Little Child, Thought of a Mage renowned,
Simple of Life and Aim, Humble in Vict'ry, crowned
By Loves that his Heart made warm and Truths that his Soul divined;
Though in these Later Years the Tears and the Toils be done,
Though through the Long Day's Heat he hath journeyed high and far,
Though the Doors of Ten thousand Hearts are open Everyone
And the Heart-fires signal, "Come to the Board where thy Lovers are,"
Still strives the Pilgrim on in the Glow of the Setting Sun,
Joyfully to the Crest where brightens the Evening Star.

GEORGE M. P. BAIRD.

THE RIDDLES OF MIZAR AND BETA AURIGAE.*

WILLIAM H. KNIGHT.

One of the most interesting stars in the sky is known by the Biblical and Arabic name of Mizar. It is in the angle of the Dipper handle and is attended by a naked-eye companion Alcor. But telescopically Alcor is quite distant and a much smaller and closer companion is revealed, whence we have that not uncommon group—a triple star.

Now we may use the most powerful telescope known and this primary sun Mizar, round which the two companions are supposed to revolve, remains a single point of light. No telescopic aid has succeeded in resolving it into a double star. And yet we know that it consists of two mighty suns, far exceeding our own in mass and brightness.

No astronomical event surpasses this discovery as an example of patient research, brilliant play of imagination, and unerring logical deduction. It is also a splendid example of the coördination of various scientific aids in pointing to and arriving at irresistible conclusions.

In the year 1889 Director Edward C. Pickering of the Harvard Observatory, while engaged in studying the spectrum of various stars to ascertain their chemical elements, happened to direct special attention to Mizar, and he noticed that the spectrum lines which are usually single and sharp, were in this instance found to be double.

On repeating his observations these duplicate lines gradually closed up, and then after a few weeks they opened out again. After continuing his observations for some months, he made the surprising discovery that the strange phenomenon was periodical—they closed and opened with unvarying regularity every fifty-two days. He called the attention of other astronomers to this peculiar play of the spectral lines and their observations confirmed his discovery.

The Mystery Solved.

There was much speculation and various theories were put forth to solve the perplexing riddle. Now it was already known that when a luminous body is approaching the observer, the

* Reprinted from the Los Angeles Times, May 4, 1912.

lines of the spectrum are shifted toward the violet end of the spectrum, and on the other hand, when the luminous body is receding the lines are shifted in the opposite direction—toward the red end.

The happy thought struck Professor Pickering that possibly two great suns were revolving, in the line of sight, round a common center of gravity. While they are mutually approaching and receding, their spectrum lines are opened out in opposite directions, but when, at the end of fifty-two days, they have completed half of their orbital motion, and are crossing the line of sight, neither approaching nor receding, their lines are closed up and remain single.

Here was the evident solution of the mystery, and it was at once accepted by the astronomical world. But now a deeper problem confronted the scientific mind. What was the mass of these two worlds? What was their distance apart? What was the velocity of their orbital motions? At first blush this would seem an impossible task. Even the distance of Mizar was not known. That it was far more than 100 light years distant was certain, for it subtends no measurable parallax.

The answer to the last of the above trio of questions came first. The extent to which a spectrum line is shifted is a measure of the velocity with which a luminous body is approaching or receding. In the case of Mizar the displacement was remarkable, showing a velocity of about 100 miles per second.

How the Masses of Mizar were Determined.

Next, an abstruse mathematical formula showed that in 104 days the two suns move through an orbit of about the same dimensions as that of the planet Venus in our solar system—140,000,000 miles in diameter. But it requires 225 days for Venus to complete its revolution around the sun. That velocity is governed by the respective masses of the two bodies—the sun and Venus. If Venus should go slower it would fall into the sun; if it should go faster it would fly off into distant space.

What then must be the masses of two bodies, on opposite sides of an orbit as large as that of Venus, which would be compelled by the force of their mutual attractions to complete their revolution through that immense orbit in 104 days instead of 225? it was demonstrated that these two bodies must each have masses about twenty times that of our sun.

Extended observations and a careful review of these figures

only confirmed the astounding conclusions. It was the beginning of a new era in astronomical research. Here was a star presenting only a single point of light under the most powerful telescopes, even its distance across the unfathomable void so great that its parallax could not be measured, yet absolutely proven by spectrum analysis to consist of two gigantic suns, moving with unthinkable velocity in orbits whose dimensions were determined with precision.

The Quadruple System of Mizar.

But the picture is not yet complete. Mizar, this spectroscopic double, has long been known to have a companion fourteen seconds of arc distant. It is a bright sun, perhaps equal in size to our own, and shines with a brilliant white light. Let us give play to our imagination but keep entirely within the bounds of scientific probability. We will call the companion sun Lucifer and place it three times the distance of Neptune from its primary, or about 8,000,000,000 miles from Mizar.

Now suppose an inhabited planet like the earth is revolving around Lucifer. At that distance the two giant components of Mizar would present two small but brilliant round disks, affording far more light than our full moon. They would constantly be approaching each other till they apparently coalesced into one sun, and then they would separate to their widest distance apart. These complete phases would occupy fifty-two days. Always in their night sky these two mysterious far-off suns, glowing with supernal beauty, would rise and set with the regularity of clockwork.

But Lucifer makes its grand revolution around the central suns in a period of about 600 years; consequently it requires that length of time for these double suns to thread their way through a belt of stars extending entirely around the celestial sphere. Not till some Copernican genius reasons out the mystery will their astronomers suspect that their own magnificent Lucifer is a subordinate body moving in a vast orbit around these two dancing lights, and governed as absolutely by them as their humble earth is governed by its resplendent Lucifer.

But there is still another possible member of this magnificent Mizar group, the barely visible, naked eye companion, known as Alcor. But is it a companion, physically connected with the Mizar system? All the so-called fixed stars have a small

proper motion in space. That motion varies from a minute fraction of a second of arc in the course of a year to seven seconds in the case of Groombridge 1830, and it also varies widely in direction.

Now in the case of Alcor, the proper motion is exactly the same as that of Mizar, and its direction is precisely the same. But as yet there has been no observed approach to its assumed principal. If it is revolving in an orbit, that orbit cannot be less than a period of 5000 years. Small and insignificant as that star appears in our ken, it is a mighty sun many times larger than our own, and must exert an important influence on all the other members of the great Mizar system.

The Wonderful System of Beta Aurigae.

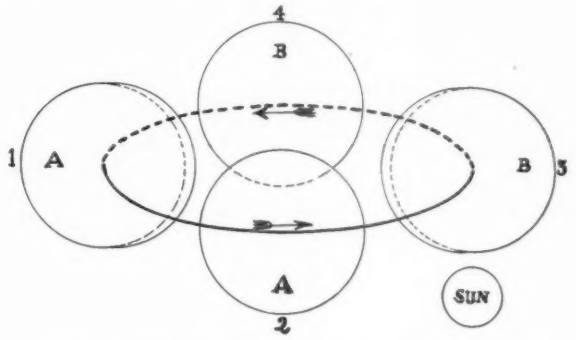
We are now prepared to consider one of the most interesting spectroscopic binaries which have thus far been studied by astronomers. One evening while Professor Pickering was observing the spectrum of the second magnitude star Beta Aurigae, about four degrees east of brilliant Capella, and midway between Orion and the North Star, he noticed that the lines broadened rapidly and then doubled in a few hours, and as quickly returned to their normal position.

The conclusion arrived at was that two very large bodies, of nearly equal mass, were following each other in a circular orbit, with the prodigious velocity of 120 miles per second. It is about 120 miles in a direct line from Los Angeles to San Diego. It takes an express train four hours to cover that distance when speeding at the rate of thirty miles per hour. Think then of a mighty sun accomplishing that distance in one second of time.

These two immense suns are swiftly revolving around a common center of gravity, in nearly perfect circles—their centers being a little more than 15,000,000 miles apart. This means that their surfaces are only about 13,000,000 miles apart, and such enormous tidal action is set up in each that the spheres are distorted into an oval shape—the small ends being directed toward each other at all times.

How do we know these facts? How can we speak of them so conclusively? At the time when the two suns are in the line of sight, there is a measurable diminution of their brightness, lasting about five hours. Evidently we do not get the full light of both orbs. The unavoidable inference is that one of

the suns is partially eclipsed by the other. When they proceed on their way past each other with respect to an earth observer, their normal luminosity is resumed.



PHASES OF THE SPECTROSCOPIC BINARY BETA AURIGAE.

The two suns, A and B, are always on opposite sides of their orbit, which is slightly tilted with respect to the observer so that A partially eclipses B when passing across the line of sight at positions 2 and 4. The spectrum lines are duplicated when A is advancing at 1 and B is receding at 3; but when they are in the positions of 2 and 4 the spectrum lines are single.

The comparative size of our own sun is shown to scale.

When, however, they proceed to the opposite extremities of what appears to us the ellipse they traverse (positions one and three of the diagram,) their combined luminosity slightly exceeds the normal. The reason is manifest. At the extremities of the ellipse their full oval form is presented to us and thus a surface slightly larger than the rounded spheres when in the line of sight accounts for the increased luminosity.

THE LIGHT WE SEE LEFT BETA IN 1776.

While the parallax of Beta Aurigae has not been determined with precision, it is approximately fixed at 136 light years, about the same as that of Regulus and Betelgueze, or about seventeen times the distance of Sirius from our system. We may pause to remark that the light from that star which enters our eyes this evening left the two blazing suns of which it is composed in the year when the Declaration of Independence was signed by the Revolutionary fathers in 1776. That factor being known other elements of the Beta system can be

computed. The two suns are gigantic and of nearly equal dimensions, each 2,250,000 miles in diameter, or nearly three times the diameter of our own sun, while their volumes are each twenty-seven times as great.

But their masses are not proportionately great, each being only two and a quarter times that of the sun. Note the difference; volumes twenty-seven times the sun; mass two and a quarter times the sun. Evidently they are magnificent orbs of glowing gas, blazing with an insufferable light, and, if located as near our system as Sirius, would far outshine Venus in splendor.

So nice and true are the astronomical data of these bodies that we are able to say with considerable assurance that owing to the retarding effect of the tremendous tides rolling over the surfaces of these two suns, they are slowly receding from each other and their periods of revolution are lengthening at the rate of seven-eighths of a second every year. We can scarcely speak with greater definiteness and precision of the planetary motions in our own solar system, where they are under the most painstaking telescopic observation.

Majesty of the Human Intellect.

Radiant energy, chemical analysis, refraction of light, photographic skill, mechanical ingenuity, and mathematical theorems, coördinated by that divine spark the human intellect, have served to transform a single point of light, a star that shows no hint of duplication under the most powerful telescope, into a startling combination of two mighty suns, revolving about a common center of gravity with amazing velocity.

And no tangible facts of science are more definite more concrete, more real, more susceptible of positive proofs than these wonderful systems of Mizar and Beta Aurigae, as revealed to our minds by Professor Pickering in his masterful chain of observations, inferences, calculations and conclusions. It is a t[illegible] intellectual achievement, worked out along the sure lines of science, and, under the wings of a thoroughly controlled imagination, penetrating with almost God-like omniscience, the hitherto invisible sanctuaries of the universe.

OBSERVATIONS OF NOVA (2) GEMINORUM.

FREDERICK C. LEONARD.

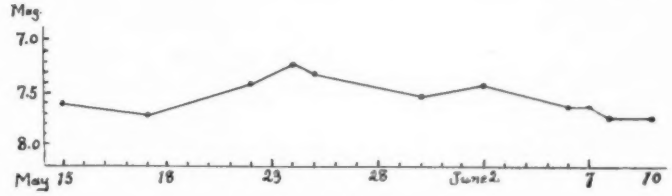
I give herewith the last set of observations of Nova (2) Geminorum which I have been able to obtain during the star's remaining visibility in the evening sky. After June 10th, (the date of my last observation), it was impossible here in the city to follow the Nova further, on account of its proximity to the horizon and consequently unfavorable position in the twilight, haze, smoke, etc. Telescope used, 3-inch refractor.

OBSERVATIONS OF NOVA (2) GEMINORUM

1912 May 13—June 10.

C.S.T. of 1912	Obs'n. h	m	Mag.	Comparison Stars	Color
May 13	8	15	7.6	BD. +32° 1433 and 1437	Red.
17	8	20	7.7	"	Red.
22	9	0	7.4	"	Red.
24	9	5	7.2	"	Light red.
25	8	25	7.3	"	Rather light red.
30	8	25	7.5	"	Rather light red.
June 2	8	30	7.4	"	Very light red.
6	8	40	7.6	"	Rather deep red.
7	8	35	7.6	"	Rather deep red.
8	8	40	7.7	"	Rather deep red.
10	8	35	7.7	"	Rather deep red.

Following is the light curve of the Nova for period 1912 May 13—June 10, plotted from the above values of magnitude.



LIGHT CURVE OF NOVA (2) GEMINORUM, 1912 May 13—June 10.

Observations of the Nova during the past month have been fewer than I could have wished, due to the considerable cloudiness prevailing throughout May and the early part of June, particularly that in the west, where the star has of late been located for study.

A reference to the light curve of the Nova, (which is in itself quite explanatory and sufficient without an accompanying description), will reveal that from first to last of the period therein graphically represented the star has lost very little in magnitude, that the latter's greatest activity has been marked by two fairly distinct rises in brilliancy, namely those reaching their culminations on May 24 and June 2, respectively, and that the mean of all of the star's variations in brightness could very readily be defined by a straight horizontal line, drawn through approximately the 7.5-magnitude division on the vertical scale. I would call special attention to the fact that on both May 24 and June 2, (the dates of its greatest brilliancy during the month), the Nova has been at its lightest in color, (that is, for this period), as a glance at the table of observations will confirm, and that as it has waxed and waned, it has lightened and deepened in hue accordingly, (which behavior I have almost without exception found to be peculiar to the star), until the color finally reached by it at its faintest has been a deep red.

Such then is the history of this wonderful Nova (2) of Gemini for the course of its appearance in the night sky.

1338 Madison Park, Chicago, Ill.,
June 20, 1912.

P. S.—In the list of observations contained in my article in the May issue, the estimation of mag. of the Nova on Mar. 15, due to an error in the printing, should read "4.2" instead of "4.1." Likewise, in the article in the June-July number, the word "it," following "made use of," in the second descriptive paragraph on p. 379, should obviously be omitted. F.C.L.

NOTE ON THE HYPOTHESIS OF M. BIRKELAND RELATIVE TO THE NATURE OF THE RINGS OF SATURN*

P. STROOBANT.

M. Birkeland† criticises the hypothesis of Maxwell, already suggested by Cassini II in his elements of astronomy (1715), according to which the rings of Saturn would be constituted of a multitude of corpuscles revolving around the planet in accordance with the laws of Kepler.

* Extract from the Bulletin of the Royal Academy of Belgium, November 1911. Traslated by Miss Isabella Watson.

† Comptes Rendus de l'Academie des sciences de Paris, Aug. 7, 1911.

According to the author of the note inserted in the *Comptes Rendus*, the rings would be produced by an electric radiation of the planet.

Let us say to begin with, that the photographs of rings artificially obtained by M. Birkeland, are not, in our judgment, of a nature to convince astronomers that the phenomenon described really has anything to do with the existence of the rings of Saturn.

The researches of Maxwell, Hirn, etc., have shown that the hypothesis of independent corpuscles enables us to explain the almost indefinite existence of the rings of Saturn, which, if they were formed of continuous matter, solid or fluid, would be in a state of unstable equilibrium or would be continually drawing nearer to the planet.

Contrary to what M. Birkeland seems to think, the slight thickness of the rings is not an obstacle to their permanence; even adopting the value of 21 kilometers, which he gives as Russell's estimate, it is sufficient to assume that the inclination of the orbits of the corpuscles to the plane of the equator of Saturn does not exceed 20″ or 30″; and there is nothing abnormal in this, it being granted that, according to H. Struve, the inclinations are respectively 1′.4 and 4′.0 for Enceladus and Dione, the second and fourth satellites of Saturn.

The small mass of the ring certainly does not constitute an objection to Maxwell's theory; the smallness of the mass of the ring in proportion to that of the planet is on the contrary, a condition of stability.*

Besides, it is well known, that the value found for the mass is rather uncertain; it results from the combination of the displacement of the line of nodes or of the line of apsides of certain satellites, determinations moreover that are very delicate.

The researches of Seeliger, based on the photometric observations made by Müller, at Potsdam, have confirmed the hypothesis of Maxwell.

On the other hand, the nature of the spectrum and the displacement of the lines, measured by Keeler, Deslandres, Belopolsky, etc., would seem to bring up a most serious objection to the bold theory of M. Birkeland.

Finally, we do not see how one could explain by this hypothesis the periodical disappearance of the rings when their plane

* J. C. Maxwell, *On the Stability of the motion of Saturn's Rings*, p. 25,— Tisserand, *Mécanique Céleste*, t. II, p. 183.

passes between the sun and the earth; and especially the shadows, so distinct and *absolutely black*, cast by the planet upon the rings and by these upon the globe of Saturn.

For these various reasons, mechanical and physical, we believe that the hypothesis of Maxwell will justly continue to be generally accepted by astronomers.

PLANET NOTES FOR SEPTEMBER AND OCTOBER, 1912.

C. H. GINGRICH.

The sun will move southward rapidly during these months. It will change its declination from 8° 20′ north on September 1 to 13° 46′ south on October 30. It will cross the equator on September 22, the time of the autumnal equinox and will move eastward through the constellations Leo and Virgo into the constellation Libra. About the middle of October the sun will pass very near the bright star Spica. This star will be invisible at this season because of the nearness of the sun.

The phases of the moon for these months are as follows;

Last Quarter	Sept. 4 at	7 A. M.	C. S. T.
New Moon	10 "	10 P. M.	"
First Quarter	18 "	2 A. M.	"
Full Moon	26 "	6 A. M.	"
Last Quarter	Oct. 3 at	3 P. M.	C. S. T.
New Moon	10 "	8 A. M.	"
First Quarter	17 "	8 P. M.	"
Full Moon	25 "	9 P. M.	"

Mercury at the beginning of September will be visible on the eastern horizon just before sunrise. It will be at its greatest elongation west on September 7, and will then approach the sun and pass on the side opposite that of the earth on October 3. It will continue to swing toward the east and will appear on the western horizon just after sunset at the close of October.

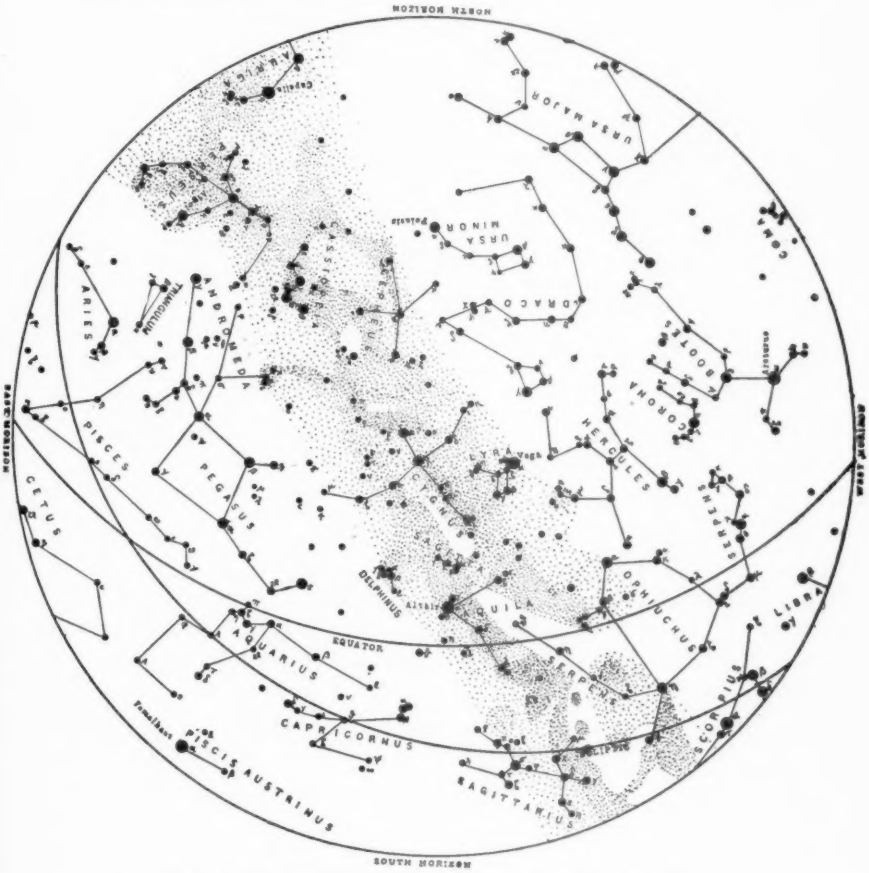
Venus during this period will be the evening star. By the end of October it will be about two hours above the horizon at sunset.

Mars at the beginning of this period will be a little more than an hour east of the sun. It will not move quite so rapidly as the sun and at the end of October it will be only a few minutes east of the sun. The sun will pass Mars on November 4. Mars will not be visible during these two months.

Jupiter will be visible in the southwest after sunset during these two months. It will be lower in the sky each day than on the preceding day. It may easily be recognized, being the brightest object in that part of the sky in the early part of September. In the latter part of October Venus will also be in that part of the sky and the two bright objects will present a very interesting sight

Saturn on September 16 stops moving eastward and begins a slow motion westward. This is called a retrograde motion. At the beginning of the period it will be near the meridian at sunrise, and at the close of the period it will rise about two hours after sunset.

Uranus and *Neptune* will both be in quadrature about October 20. Uranus will be 90° east of the sun and Neptune 90° west of the sun at this time. Hence at noon Neptune will be on the western horizon and Uranus will be on the eastern horizon. Neptune will be in the constellation Gemini, and Uranus in Capricornus.



THE CONSTELLATIONS AT 9:00 P. M. SEPTEMBER 1, 1912.

Total Eclipse of the Sun October 10, 1912.—The path of totality will cross South America from a point near Quito, Ecuador, to near Rio Janeiro, Brazil; thence southeast across the Atlantic Ocean. The best place for observing the eclipse will be in the vicinity of Rio Janeiro where totality will last nearly two minutes. The eclipse will be partial in Florida, the West Indies, Central and South America, and the extreme southern part of Africa. For chart of the path of the eclipse and data for calculating the times see the January 1912 number of POPULAR ASTRONOMY.

Partial Eclipse of the Moon Sept. 26.—On the morning of Sept. 26 there will be a partial eclipse of the moon, visible in the western part of the United States, over the Pacific Ocean, and in eastern Asia and Australia. The following are the times of the different phases of the eclipse:

	Greenwich M.T.		Central Standard Time	
	h m		h m	
Moon enters penumbra	Sept. 25 21 15.3		Sept. 26 3 15	a. m.
Moon enters shadow	23 03.1		5 03.1	"
Middle of the eclipse	23 44.7		5 44.7	"
Moon leaves shadow	26 0 26.3		6 26.3	"
Moon leaves penumbra	2 13.7		8 13.7	"

At the middle of the eclipse only one eighth of the diameter of the moon's disk will be within the umbra of the earth's shadow, so that the eclipse will not be a very noticeable phenomenon.

Conjunction of (21) Lutetia with Jupiter.—Dr. Ristenpart, in a telegram June 4, 1912, called attention to a close conjunction and possible transit of the planetoid (21) Lutetia with Jupiter June 7.61 Greenwich mean time. The date was later changed to June 6.98. No reports of observation of this conjunction have as yet come to hand.

Phenomena of Jupiter's Satellites.

Central Standard Time.

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

1912	h	m					h	m			
Sept.	2	7	26	I	Oc.	Dis.	Sept. 26	8	30	I	Sh. Eg.
		8	51	I	Oc.	Dis.	27	5	37	I	Ec. Re.
	3	6	57	I	Tr.	Eg.		6	17	II	Oc. Dis.
		8	15	I	Sh.	Eg.	29	5	39	II	Sh. Eg.
	4	6	03	II	Tr.	Eg.	Oct. 3	6	46	III	Ec. Re.
		7	12	III	Oc.	Dis.		7	04	I	Tr. In.
		8	36	II	Sh.	Eg.		8	10	I	Sh. In.
		9	34	III	Oc.	Re.	6	5	32	II	Sh. In.
	10	6	39	I	Tr.	In.		6	05	II	Tr. Eg.
		7	55	I	Sh.	In.		8	15	II	Sh. Eg.
		8	74	I	Tr.	Eg.	10	6	34	III	Oc. Re.
		10	10	I	Sh.	Eg.		8	25	III	Ec. Dis.
	11	5	58	II	Tr.	In.	11	6	12	I	Oc. Dis.
		7	19	I	Ec.	Re.	12	5	48	I	Tr. Eg.
		8	29	II	Sh.	In.		6	49	I	Sh. Eg.
		8	41	II	Tr.	Eg.	13	6	06	II	Tr. In.
	13	6	05	II	Ec.	Re.		8	08	I	Sh. In.
	15	6	17	III	Sh.	In.		8	50	I	Tr. Eg.
		8	44	III	Sh.	Eg.	15	5	54	II	Ec. Re.
	18	5	48	I	Oc.	Dis.	19	5	33	I	Tr. In.
		8	38	II	Tr.	In.		6	28	I	Sh. In.
		9	13	I	Ec.	Re.	20	5	50	I	Ec. Re.
	19	6	34	I	Sh.	Eg.	28	5	08	I	Sh. Eg.
	22	7	49	III	Tr.	Eg.		5	26	III	Tr. Eg.
	26	6	15	I	Sh.	In.		6	12	III	Sh. In.
		7	19	I	Tr.	Eg.	31	5	20	II	Sh. Eg.

Occultations visible at Washington.

Date 1912		Star's Name	Magnitude	IMMERSION. Washington M.T. h	m	Angle f'm N. °	EMERSION. Washington M.T. h	m	Angle f'm N °	Duration h	m
Sept.	5	49 Aurigæ	5.1	13	18	57	14	08	289	0	50
	5	54 Aurigæ	5.8	15	19	14	15	42	333	0	23
	29	ζ Arietis	5.0	11	06	28	12	05	269	0	59
	30	36 Tauri	5.6	8	09	7	8	59	242	0	50
	30	χ Tauri	5.3	17	49	106	18	59	243	1	10
Oct.	1	354 B Tauri	6.4	16	24	64	17	45	279	1	21
	4	λ Cancri	5.9	12	18	154	12	46	218	0	28
	4	28 Cancri	6.1	15	21	66	16	18	316	0	57
	4	ν′ Cancri	5.7	17	00	40	17	31	353	0	31
	13	48 B Scorpii	4.9	5	12	123	6	23	259	1	11
	24	ζ Piscium	5.6	6	45	63	7	53	224	1	08
	25	12 H′ Arietis	6.3	7	29	81	8	28	208	0	59
	25	19 Arietis	5.8	15	02	78	16	11	232	1	09
	26	40 Arietis	6.0	5	19	52	6	09	256	0	50
	27	104 B Tauri	5.5	7	53	11	8	26	299	0	33
	29	406 B Tauri	5.6	8	18	52	9	04	285	0	46
	31	ω Cancri	5.9	9	57	64	10	42	304	0	45
	31	4 Cancri	6.2	10	17	129	11	00	239	0	43

VARIABLE STARS.

Designation of Recently Discovered Variable Stars.

The following list of variable stars, whose variability has been established during the first half of this year, was published in *A. N.* 4579. It is reproduced here for the benefit of those of our readers who are interested in the study of variable stars and who may not have access to the *Astronomische Nachrichten.*

No.	Prov. No. A.N.		Position 1900 R. A. h	m	s	Decl. °	′	Magnitude Max. m	Min. m	
1	45.1911	TV Cassiopeiae	0	13	55	+58	35.0	7.3	8.5	v
2	6.1907	UZ Andromedae	1	10	27	+41	13.3	8.0	<13	ph
3		Z Piscium	1	10	38	+25	14.4	7.4	8.1	v
4	52.1911	W Phoenicis	1	15	51	−56	26.6	8.5	16.0	ph
5	53.1911	UY Andromedae	2	32	9	+38	44.1	11.0	<14.0	ph
6	54.1911	Y Arietis	2	35	2	+30	46.2	10.0	11.5	ph
7	37.1907	TW Cassiopeiae	2	37	37	+65	18.2	8.0	8.5	v
8	13.1911	TX Persei	2	41	47	+36	33	9.5	11	ph
9		Z Eridani	2	43	9	−12	52.6	6.4	7.7	v
10	38.1907	TX Cassiopeiae	2	44	17	+62	22.2	8.8	9.3	v
11		RR Eridani	2	47	20	−	8 40.6	7.2	8.1	v
12	200.1907	X Arietis	3	3	6	+10	3.9	8.8	9.5	ph
13	203.1907	RT Eridani	3	29	36	−16	29.7	9.6	<11.0	ph
14	56.1911	U Fornacis	3	40	12	−25	32	9.8	<13.0	ph
15	46.1911	SY Tauri	3	42	51	+23	13.2	10.8	11.5	ph
16	208.1907	RS Eridani	4	13	29	−18	45.2	8.9	13.0	ph
17	41.1910	SZ Tauri	4	31	26	+18	20.4	7.2	7.7	ph
18	72.1907	S Reticuli	4	31	36	−63	11.9	8.8	<11.5	ph
19		ST Camelopard	4	40	51	+67	59.6	7.0	8.3	v
20	57.1911	T Caeli	4	43	45	−36	23.2	8.7	10.3	ph
21	74.1907	T Doradus	4	43	58	−59	59.5	8.8	<11.5	ph
22		TT Tauri	4	45	15	+28	21.3	8.1	8.8	v
23	75.1907	U Pictoris	4	47	36	−50	49.6	10.0	11.5	ph
24	3.1908	UX Aurigae	5	8	18	+49	25.9	8.1	8.7	v
25	82.1907	U Doradus	5	9	35	−64	26.5	9.1	<11.5	ph
26	58.1911	UV Aurigae	5	15	18	+32	24.7	9.2	10.6	ph
27		TU Tauri	5	39	6	+24	22.6	8.7	9.5	v
28	59.1911	W Pictoris	5	40	27	−46	29.9	11.0	<15.0	ph

Designation of Recently Discovered Variable Stars.—Continued.

No.	Prov. No. A.N.		Position 1900 R. A. h m s	Decl. ° ′	Magnitude Max. m	Min. m	
29		TU Geminorum	6 4 41	+26 2.0	7.4	8.7	v
30		TV Geminorum	6 5 51	+21 53.4	6.7	8.0	v
31	84.1907	RW Puppis	6 6 43	−50 11.2	9.0	<11.0	ph
32	85.1907	V Pictoris	6 11 58	−59 53.1	9.2	11.0	ph
33		UU Aurigae	6 29 40	+38 31.6	6.2	6.7	v
34	60.1911	UW Aurigae	6 50 16	+41 14.3	9.6	12.6	ph
35	194.1907	X Canis maj.	6 52 36	−23 50.0	8.9	10.1	ph
36	63.1905	TW Geminorum	7 1 17	+22 39.8	7.7	8.2	v
37	61.1911	RY Monocerotis	7 2 6	− 7 24.2	12.8	14.0	ph
38	49.1901	W Canis maj.	7 3 23	−11 46.0	8.3	10.0	ph
39	50.1901	Y Lyncis	7 20 55	+46 11.5	7.8	8.4	ph
40		W Canis Min.	7 43 27	+ 5 38.5	9.8	11.3	ph
41		RY Hydrae	8 14 53	+ 3 4.8	8.3	9.6	v
42	27.1909	ST Velorum	8 41 50	−50 11.9	9.7	10.5	ph
43	4.1912	RT Cancri	8 52 50	+11 13.9	7.4	9.3	v
44	164.1907	RZ Hydrae	9 19 53	− 6 21.8	10.0	<11.5	ph
45	166.1907	T Leonis min.	9 42 33	+33 45.2	9.5	11.5	ph
46	62.1911	SU Velorum	9 46 0	−41 33.7	9.2	10.5	ph
47	95.1910	U Leonis min.	9 48 38	+36 35	10	<12	ph
48	9.1907	TZ Carinae	10 42 30	−65 5.3	8.4	9.6	ph
49	145.1907	SS Velorum	10 48 38	−52 53.4	10.0	12.0	ph
50	152.1907	TY Carinae	10 48 43	−72 14.3	9.8	11.5	ph
51	153.1907	RR Muscae	11 35 0	−72 0.4	8.6	10.2	ph
52	155.1907	RS Muscae	12 17 27	−74 56.9	8 8	10.6	ph
53	156.1907	S Corvi	12 32 22	−16 42.8	8 8	10.5	ph
54	55.1901	SW Virginis	13 8 55	− 2 16.6	7.4	8.8	ph
55	64.1911	UY Centauri	13 10 43	−44 10.6	9.0	9.6	ph
56	157.1907	UX Centauri	13 15 31	−63 41.6	9.0	10.5	ph
57	42.1911	SS Hydrae	13 25 1	−23 8.0	7.4	8.1	v
58	5.1912	X Canum ven.	14 1 0	+38 2	10	10.8	v
59	87.1910	UV Draconis	14 41 6	+56 31.7	9.8	10.6	ph
60	34.1911	RY Bootis	14 45 14	+23 26.8	7.1	7.4	v
61		X Triang. austr.	15 4 43	−69 42.1	8.2	10.0	ph
62	6.1912	RR Serpentis	15 26 24	+ 1 49.2	10	11.5	v
63	29.1911	ST Librae	15 40 53	−18 25.1	13.5	15.7	ph
64	11 .1908	SS Librae	15 43 27	−15 13.8	9.6	10.6	ph
65	217.1907	Z Normae	15 57 49	−46 1.1	8 6	10.0	ph
66	218.1907	RR Lupi	15 58 37	−34 6.2	10.0	<11.5	ph
67	113.1907	Y Triang. austr.	16 5 17	−61 50.2	9.8	<11.5	ph
68	110.1910	RR Triang. austr.	16 9 24	−62 29.2	9.4	10.3	ph
69	111.1910	RS Triang. austr.	16 13 12	−61 12.7	10.1	<11.5	ph
70	7.1912	UY Herculis	16 29 42	+38 16.9	8.3	9.0	v
71	114.1907	RX Arae	16 43 35	−60 54.4	10.3	11.1	ph
72	116.1907	Z Triang. austr.	16 45 5	−65 2.2	9.5	11.5	ph
73	221.1907	AK Scorpii	16 48 2	−36 43.4	8.7	10.0	ph
74	223.1907	AH Scorpii	17 4 48	−32 12.0	9.6	11.3	ph
75	117.1910	RY Arae	17 13 15	−51 1.0	8.9	10.3	ph
76	83.1911	TW Ophiuchi	17 23 50	−19 23.6	8.0	8.7	v
77	21.1908	AI Scorpii	17 49 42	−33 48.0	9.5	11.0	ph
78	22.1908	RW Coronae austr.	17 52 29	−37 52.3	8.7	9.7	ph
79	45.1906	UW Draconis	17 55 32	+54 40.5	7.0	7.6	v
80	27.1908	XY Sagittarii	18 5 19	−16 29.1	9.8	11.3	ph
81	28.1908	AO Sagittarii	18 5 59	−29 52.9	9.5	10.7	ph
82	65.1911	AI Sagittarii	18 10 42	−21 36	11.8	<15.0	ph
83	32.1908	XZ Sagittarii	18 15 57	−25 17.1	8.9	11.2	ph
84	66.1911	AK Sagittarii	18 22 18	−16 50	10.9	<15.0	ph
85	68.1911	RV Coronae austr.	18 32 57	−42 41.2	12.2	15.5	ph
86	129.1910	RV Telescopii	18 35 43	−51 43.4	9.0	10.2	ph
87	130.1910	RW Telescopii	18 35 59	−45 52.6	9.0	10.2	ph
88	37.1908	SS Scuti	18 38 18	− 7 49.8	7.5	8.4	ph

Desgnation of Recently Discovered Variable Stars.—Continued.

No.	Prov. No. A.N.		Position 1900 R. A. h m s	Decl. ° ′	Magnitude Max. m	Min. m	
89		RT Coronae austr.	18 38 42	−38 52	11.0	<13.5	ph
90	38.1908	YY Sagittarii	18 38 43	−19 29.8	8.8	9.7	ph
91	39.1908	ZZ Sagittarii	18 43 3	−34 47.6	8.9	10.5	ph
92	140.1908	YZ Sagittarii	18 43 42	−16 50.1	7.5	8.3	ph
93	62.1908	ST Scuti	18 45 56	−13 2.6	10.0	14.0	ph
94	63.1908	SU Scuti	18 47 16	−12 37.9	13.4	15.0	ph
95	65.1908	SV Scuti	18 48 1	−14 19.1	12.0	15.4	ph
96	67.1908	SW Scuti	18 48 16	−12 46.3	12.0	<16.0	ph
97	68.1908	SX Scuti	18 49 14	−11 5.8	13.6	15.5	ph
98	69.1911	UW Aquilae	18 52 27	+ 0 18.7	9.6	11.0	ph
99	73.1908	AA Sagittarii	18 53 36	−13 26.7	13.9	<15·8	ph
100	70.1911	UV Aquilae	18 53 58	+14 13.7	9 6	11.6	ph
101	103.1908	AB Sagittarii	18 56 18	−13 4.7	14.0	15.5	ph
102	78.1908	AC Sagittarii	18 56 30	−12 36.8	14.5	<16.0	ph
103	80.1908	AD Sagittarii	18 58 16	−14 0.9	12.1	15.2	ph
104	82.1908	AE Sagittarii	18 59 56	−12 50.8	12.0	16.0	ph
105	108.1908	AF Sagittarii	19 0 59	−12 29.5	14.0	<16.0	ph
106	42.1908	AG Sagittarii	19 1 16	−29 1.2	9.0	<13.0	ph
107	86.1908	AH Sagittarii	19 3 23	−12 30.7	10.5	15.8	ph
108	18.1907	RU Coronae austr.	19 10 30	−39 47	9.8	12.4	ph
109	71.1911	AL Sagittarii	19 11 54	−17 39	10.0	14.0	ph
110	72.1911	AM Sagittarii	19 16 16	−32 19.4	10.3	14.0	ph
111	35.1910	AV Cygni	19 16 45	+29 19.4	9.8	10.7	ph
112	73.1911	AN Sagittarii	19 21 12	−18 43	9.4	15.0	ph
113		UX Draconis	19 25 7	+76 21.7	6.7	7.5	v
114		AW Cygni	19 25 48	+45 50.2	8.0	8.6	v
115	19.1907	UU Aquilae	19 52 0	− 9 37	9.6	<11.5	ph
116	84 1911	AX Cygni	19 53 59	+43 59.6	8.2	8.6	v
117	74.1911	X Sagittae	20 0 41	+20 21.8	10.0	12.0	ph
118	85.1911	AY Cygni	20 6 16	+41 12 0	8.9	10.2	v
119		AZ Cygni	20 54 32	+46 4.8	8.1	9.4	v
120	77.1911	X Microscopii	20 58 24	−33 40	9.3	<15.0	ph
121	78.1911	TZ Pegasi	21 4 18	+15 38	10.1	<14.0	ph
122	125.1908	SW Aquarii	21 10 11	− 0 19.6	10.0	11.0	ph
123	125.1908	RY Aquarii	21 14 51	−11 13.6	9.2	10.2	ph
124	126.1908	RZ Aquarii	21 17 46	− 7 30.4	11.0	<12.5	ph
125	48.1911	TV Pegasi	21 22 5	+16 9	10.5	<12.5	ph
126		SW Cephei	21 23 19	+62 8.4	8.0	9.0	v
127	79.1911	U Gruis	21 25 18	−45 29.1	9 8	14.0	ph
128	168.1908	RR Indi	21 38 24	−65 46.0	9.8	10.8	ph
129	124 1907	TW Pegasi	21 59 27	+27 51.8	7.2	7.8	ph
130	132.1908	TX Pegasi	22 13 25	+13 6.5	10.0	11.2	ph
131	133.1908	SS Aquarii	22 14 32	−14 54.3	11.0	12 5	ph
132	134.1908	ST Aquarii	22 15 47	− 7 28.1	9.2	9.9	ph
133	22.1907	RX Lacertae	22 45 24	+40 30	8.3	9.0	v
134	136.1908	SU Aquarii	22 46 46	−13 28.5	9.8	10.5	ph
135	80.1911	V Piscis austr.	22 49 50	−30 8.7	8.4	9 7	ph
136	171.1908	SV Aquarii	23 17 34	−11 22.2	8.4	9.4	ph
137	31.1911	TY Pegasi	23 24 54	+12 59.6	9.4	<10.6	ph
138	43.1911	Nova Arietis	2 42 56	+16 56.8	9.5	<12	v
139	98.1910	Nova Arae	16 33 1	−52 13.8	6.0	<12	v
140	96.1910	Nova Sagittarii 2	17 53 49	−27 32.8	7.8	<12	ph
141	22.1911	Nova Sagittarii 4	18 0 27	−27 26.5	10.3	<16	ph

Approximate Magnitudes of Variable Stars on July 1, 1912.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900. h m	Decl. 1900. ° ′	Magn.
T Cassiop.	0 17.8	+55 14	8.4*d*	RU Librae	15 27.7	−14 59	<12.0
U Cassiop.	40.8	+47 43	<12.0	S Urs. Min.	33.4	+78 58	11.5 *i*
RW Androm.	41.9	+32 8	<12.0	R Cor. Bor.	44.4	+28 28	6.7
W Cassiop.	49.0	+58 1	11.6*d*	X Cor. Bor.	45.2	+36 35	9.7 *i*
RU Androm	1 32.8	+38 10	10.2	R Serpentis	46.1	+15 26	5.8
Y Androm.	33.7	+38 50	<12.0	RU Herculis	16 6.0	+25 20	<11.0
X Cassiop.	49.8	+58 46	10.6 *i*	U Herculis	21.4	+19 7	11.8*d*
o Ceti	2 14.3	− 3 26	4.2	W Herculis	31.7	+37 32	7.8
RR Persei	21.7	+50 49	10.3 *i*	R Draconis	32.4	+66 58	<11.0
T Camelop.	4 30.4	+65 57	10.1*d*	S Herculis	47.4	+15 7	11.6
R Aurigae	5 9.2	+53 28	9.4 *i*	RR Scorpii	50.2	−30 25	8.2 *i*
R Lyncis	6 53.0	+55 28	<12.0	RV Herculis	56.8	+31 22	<12 0
T Cancri	8 51.0	+20 14	8.7	R Ophiuchi	17 2.0	−15 58	<12.0
Y Draconis	9 31.1	+78 18	<13.0	Z Ophiuchi	14.5	+ 1 37	8.2
R Leo. Min.	39.6	+34 58	11.0	T Herculis	18 5.3	+31 0	8.4
R Leonis	42.2	+11 54	6.3*d*	X Ophiuchi	33 6	+ 8 44	8.2
R Urs. Maj.	10 37.6	+69 18	13.2	R Scuti	42.2	− 5 49	6.1*d*
W Leonis	48.4	+14 15	13.0	R Cygni	19 34.1	+49 58	12.7
R Crateris	55.6	−17 47	9.2	RT Cygni	40.8	+48 32	11.7
S Leonis	11 5.7	+ 6 0	12.9	X Cygni	46.7	+32 40	10.3 *i*
R Com. Ber.	59.1	+19 20	9.0	SV Cygni	20 6.5	+47 35	8.5
SS Virginis	12 20.1	+ 1 19	8.7*d*	RS Cygni	9.8	+38 28	8.0
T Can. Ven.	25.2	+32 3	9.4	R Delphini	10.1	+ 8 47	11.1*d*
T Urs. Maj.	31.8	+60 2	12.2	SX Cygni	11.6	+30 46	13.3
R Virginis	33.4	+ 7 32	7.3	U Cygni	16.5	+47 35	7.9
S Urs. Maj.	39.6	+61 38	8.5	S Delphini	38.5	+16 44	9.9
U Virginis	46.0	+ 6 6	9.4*d*	T Delphini	40.7	+16 2	<12.0
R Hydrae	13 24.2	−22 46	9.5*d*	T Aquarii	44.7	− 5 31	7.1
R Can. Ven.	44.6	+40 2	7.2 *i*	RZ Cygni	48.5	+46 59	11.3
U Urs. Min.	14 15.1	+67 15	8.9*d*	R Vulpeculae	59.9	+23 26	9.7
S Boötis	19.5	+54 16	<11.0	X Cephei	21 3.6	+82 40	<13.0
RS Virginis	22 3	+ 5 8	10.0 *i*	T Cephei	8.2	+68 5	7.7
V Boötis	25.7	+39 18	9.2*d*	W Cygni	32.2	+44 56	5.3
R Camelop.	25.1	+84 17	9.3 *i*	S Cephei	36.5	+78 10	9.9*d*
R Boötis	32.8	+27 10	11.7*d*	RV Cygni	39.1	+37 34	8.4*d*
RT Librae	15 0.8	−18 21	<10.0	RT Pegasi	59.8	+34 38	12.0
Y Librae	6.4	− 5 38	10.8*d*	R Lacertae	22 38.8	+41 51	<12.0
S Librae	15.6	−20 2	10.3*d*	V Cassiop.	23 7.4	+59 8	11.0 *i*
				R Cassiop.	53.3	+50 50	7.8*d*

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:— T. C. H. Bouton, H. C. Bancroft, Jr., Edward Gray, F. E. Hathorn, S. E. Hunter, M. W. Jacobs, Jr., J. B. Lacchini, C. Y. McAteer, W. T. Olcott, P. G. O'Reilly, E. R. Padova, E. A. Perkins, E. L. Forsyth, H. M. Swartz, H. W. Vrooman, I. E. Woods, A. S. Young.

Minima of Variable Stars of the Algol Type.

[Calculated by Mary H. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h, etc.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of minima in Sept.-Oct. 1912. d h d h d h d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.6	16 11
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	8 17; 20 14; 8 10; 20 8
U Cephei	0 53.4	+81 20	7.1— 9.2	2 11.8	10 17; 20 16; 10 15; 20 14
Z Persei	2 33.7	+41 46	9.4—12.	3 01.4	7 0; 19 5; 7 13; 19 19
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	5 5; 18 22; 9 12; 23 6
RZ Cassiop.	39.9	+69 13	6.4— 7.8	1 04.7	11 12; 23 11; 11 9; 23 8
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	6 20; 17 13; 8 16; 19 6
RX Cephei	2 58.8	+67 11	8.6— 9.1	32 07.6	30 7
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	9 4; 20 15; 7 20; 19 7
RT Persei	16.7	+46 12	9. —11.	0 20.4	12 4; 22 9; 12 18; 22 23
λ Tauri	55.1	+12 12	3.4— 4.5	3 22.9	10 19; 26 14; 12 10; 28 5
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	13 23; 25 00; 11 15; 22 17
RV Persei	4 04.2	+33 59	10.6—12.8	1 23.4	11 17; 23 14; 11 8; 23 6
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	2 13; 28 22; 12 3; 25 8
RS Cephei	4 48.6	+80 06	9.5—12.2	12 10.1	3 8; 28 4; 10 14; 23 00
RY Aurigæ	5 11.5	+38 13	10.7—11.7	2 17.5	14 11; 30 19; 11 17; 22 15
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	8 2; 20 3; 8 5; 20 6
SV Gemin;	54.6	+24 28	9.8—<11	4 00.2	10 5; 26 5; 12 6; 28 7
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	12 1; 23 12; 10 17; 22 4
U Columbæ	6 11.2	−33 03	9.4—10.2	2 19.2	9 00; 20 5; 12 15; 29 10
56,1908 Gemin.	22.	+20 37	10.8—11.5	1 08.8	14 1; 30 11; 11 9; 22 8
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	9 8; 24 14; 9 20; 25 2
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	8 18; 20 23; 3 4; 27 14
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	10 21; 21 15; 2 9; 13 3
R Canis Maj.	7 14.9	−16 12	5.9— 6.7	1 03.3	9 9; 20 18; 13 11; 30 12
RY Gemin.	7 21.7	+15 52	8.9—<10	9 07.2	6 5; 24 20; 4 3; 22 17
Y Camelop	27.6	+76 17	9.5—12.	3 07.3	12 5; 18 19; 8 15; 21 21
RR Puppis	43.5	−41 08	9.5—	6 10.3	11 23; 24 20; 7 17; 20 14
V Puppis	55.4	−48 58	4. — 5.	1 10.9	15 0; 29 13; 14 2; 28 15
X Carinæ	8 29.1	−58 53	7.8— 8.9	0 13.0	8 19; 19 15; 11 7; 22 2
S Cancri	8 38.2	+19 24	8. —10.	9 11.6	10 19; 29 18; 9 6; 28 5
S Velorum	9 29.5	−44 46	7.8— 9.5	5 22.4	9 7; 27 2; 8 23; 20 20
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	10 8; 27 5; 14 2; 30 23
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	2 3; 20 16; 9 5; 27 18
SS Carinæ	10 54.2	−61 23	12.2—12.8	3 07.2	13 9; 26 14; 9 19; 23 0
RW Urs. Maj	11 35.4	+52 34	9.3—10.3	7 07.9	8 6; 22 21; 7 13; 22 5
Z Draconis	11 40.6	+72 49	9.5—12.5	1 08.6	13 4; 26 18; 10 8; 23 21
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	3 23; 18 20; 3 17; 18 14
δ Libræ	14 55.6	— 8 07	5. — 6.7	2 07.9	8 14; 22 13; 6 12; 20 11
U Coronæ	15 14.1	+32 01	7.8— 9.0	3 10.9	8 18; 22 14; 6 9; 20 5
TW Draconis	15 32.4	+64 14	7.0— 8.9	2 19.4	9 19; 26 15; 5 2; 21 22
SW Ophiuchi	16 11.1	— 6 44	9.2—10.	2 10.7	7 9; 22 1; 6 17; 21 9
SX Ophiuchi	16 12.6	— 6 25	10.5—11.2	2 01.5	11 23; 24 8; 6 17; 25 17
R Aræ	16 31.1	−56 48	6.7— 8.	4 10.2	7 23; 25 16; 13 9; 31 1
TT Herculis	16 49.9	+17 00	8.9— 9.5	20 18.1	1 12; 22 6; 13 0
TU Herculis	17 09.8	+30 50	9.5—12.	2 06.4	10 16; 24 7; 7 21; 21 11
U Ophiuchi	11.5	+ 1 19	6. — 6.7	0 20.1	9 10; 26 5; 12 23; 29 18
SZ Herculis	36.0	+33 01	9 5—10.3	0 19.6	10 22; 27 7; 13 15; 30 0
Z Herculis	17 53.6	+15 09	6.7— 8.0	3 23.8	12 10; 28 10; 14 9; 30 8
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	9 5; 24 18; 10 6; 25 18
RS Sagittarii	11.0	−34 08	6.7— 7.8	2 10.0	12 19; 27 7; 11 19; 26 7
V Serpentis	11.1	−15 34	9.5—	3 10.9	12 15; 26 10; 10 6; 24 1
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	11 12; 22 13; 9 1; 20 2

Minima of Variable Stars of the Algol Type.—Continued.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of minima in Sept.-Oct. 1912. d h d h d h d h
RX Herculis	18 26.0	+12 32	7.8— 8.0	0 21.3	7 6; 25 1; 12 20; 30 15
SX Sagittarii	39.7	−30 36	8.6— 9.4	2 01.8	7 12; 20 0; 8 16; 21 3
RR Draconis	40.8	+62 34	9.3—13.	2 19.9	13 14; 30 14; 9 2; 26 1
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	9 17; 23 8; 13 4; 26 9
U Scuti	18 48.9	−12 44	9.0— 9.8	0 22.9	6 23; 26 2; 5 15; 24 17
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.5	6 2; 25 1; 4 12; 23 11
RV Lyræ	12.5	+32 15	11. —13.	3 14.4	14 7; 28 17; 13 2; 27 12
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	11 5; 29 2; 8 1; 25 23
U Sagittæ	14.4	+19 26	6.7— 9.0	3 09.1	13 3; 26 15; 10 4; 23 16
Z Vulpec.	17.5	+25 23	7.3— 8 5	2 10.9	11 14; 26 8; 11 1; 25 19
136.1910 Lyræ	24.3	+41 30	9.0<11.0	5 05.8	13 16; 29 10; 15 3; 30 21
SY Cygni	19 42.7	+32 28	10. —12.	6 00.2	8 1; 20 1; 8 1; 20 2
WW Cygni	20 00.6	+41 18	9.5—12.5	3 07.6	9 9; 22 16; 12 13; 25 20
SW Cygni	03.8	+46 01	9. —12.	4 13.8	6 15; 24 22; 13 5; 31 12
VW Cygni	11.4	+34 12	9.5—11.5	8 10.3	7 10; 24 6; 11 3; 28 0
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	11 6; 24 20; 8 10; 21 23
UW Cygni	19.6	+42 55	10.5—13.	3 10.8	13 2; 26 21; 10 16, 24 12
W Delphini	33.1	+17 56	9.5—11.5	4 19.4	8 6; 27 12; 7 3; 26 8
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 4; 27 14; 6 18; 25 4
Y Cygni	48.1	+34 17	7. — 8.	1 12.0	12 22; 27 21; 12 21; 27 21
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	9 23; 25 3; 10 7; 25 10
VV Cygni	21 02.3	+45 23	11. —14.	1 11.4	10 0; 24 19; 9 13; 2[illegible] 8
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	3 1; 22 10; 11 19; 31 5
UZ Cygni	55.2	+43 52	9. —11.5	31 07.3	10 16 11 24
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	9 6; 24 11; 9 17; 24 22
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	6 21; 22 10; 8 0; 23 13
TT Androm	23 08.7	+45 36	10.5—11.3	2 18.3	7 18; 24 8; 10 22; 27 12
32.1911 Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	8 15; 23 17; 8 18; 23 20
TW Androm.	23 58.2	+32 17	8.6—11.5	6 02.9	13 19; 30 6; 8 12; 25 0

Maxima of Variable Stars of Short Period not of the Algol Type.

[Calculated by Wallace F. Johnson at Goodsell Observatory]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h etc. An * following the name of a star signifies that for that star times of minima instead of maxima are given.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of maxima in Sept.-Oct. 1912. d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9·4	36 13.7	21 2; 27 16
SY Cassiop.	9.8	+57 52	9 3— 9.9	4 1.7	7 14; 23 21; 2 0; 18 7
RT Sculptor.*	0 31.5	−26 13	9.6—10.5	0 12.3	4 4; 24 15; 4 21; 25 8
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	1 4; 23 7; 4 9; 20 23
RW Cassiop.	1 30.7	+57 15	8.6— 9.4	14 19 2	6 12; 21 7; 6 2; 20 21
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	6 15; 24 12; 6 10; 24 6
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	1 13; 24 22; 6 15; 24 4
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	4 11; 22 16; 4 20; 23 1
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	3 0; 19 0; 5 0; 21 0
SX Persei	4 10.2	+41 29	10.3—11.0	4 07.1	1 9; 18 13; 5 17; 22 20
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	9 17; 20 20; 1 23; 24 6
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	6 14; 29 20; 11 11; 23 2
TT Aurigæ*	02.8	+39 27	7.8— 8.7	0 16.0	6 7; 19 15; 2 23; 22 23
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	2 10; 20 20; 3 2; 21 11

Maxima of Variable Stars of Short Period not of the Algol Type.

Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean time of maxima in Sept.-Oct. 1912.							
	h m	° ′		d h	d h		d h		d h		d h	
SY Aurigæ	5 05.5	+42 42	9.0— 9.7	10 03.3	1 22;	22	5;		2 8;		22 15	
Y Aurigæ	21.5	+42 21	9. —	3 20.6	4 3;	19	13;		4 23;		20 10	
SV Tauri*	45.8	+28 05	9.4—11.0	2 04.0	5 23;	18	22;		1 23;		21 11	
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	5 0;	21	14;		2 15;		24 18	
RS Orionis	6 16.5	+14 43	7.8— 8.5	7 13.4	3 6;	18	9;		3 12;		18 14	
T Monoc.	19.8	+ 7 08	6. — 8.	27 00.3	9 4;				6 4			
RZ Camelop	23.7	+67 06	11.0—12.8	0 11.5	4 7;	23	12;		3 2;		27 3	
W Gemin.	29.2	+15 24	6 8— 7.6	7 22.0	8 14;	24	10;		2 8;		18 4	
ζ Gemin.	6 58.2	+20 43	3.7— 4.5	10 03.7	1 1;	21	8;		1 12;		21 19	
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		22	20;	15	3			
RR Gemin.	7 15.2	+31 04	9.7—10.6	0 09.5	1 23;	21	20;		3 18;		23 14	
V Carinæ	8 26.7	−59 47	7.2— 8.0	6 16.7	7 2;	20	12;		3 21;		23 23	
T Velorum	8 34.4	−47 01	7.5— 8.5	4 15.3	2 1;	20	15;		4 13;		23 2	
W Carinæ	9 19.2	−55 32	7.5— 8.5	4 08.9	4 10;	26	7;		5 0;		26 21	
S Antliæ*	27.9	−28 11	6.7— 7.8	0 07.8	3 17;	23	3;		6 3;		19 2	
W Ursæ Maj.	9 36.7	+56 24	8.	0 04.0	6 10;	19	19;		3 3;		23 3	
RR Leonis	10 02.1	+24 03	9.1—10.0	0 10.9	3 9;	23	17;		7 7;		20 21	
ST Ursæ Maj.*	11 22.4	+45 44	6.7— 7.2	8 19.2	8 14;	26	5;		5 0;		22 14	
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	1 14;	21	10;		4 15;		24 10	
S Muscae	12 07.4	−69 36	6.5— 7.3	9 15.8	8 21;	28	5;		7 20;		27 4	
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	3 19;	20	21;		2 7;		19 9	
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	7 7;	20	19;		4 6;		24 11	
R Crucis	18.1	−61 04	6.8— 8.0	5 19.8	6 8;	23	19;		5 11;		22 22	
S Crucis	48.4	−57 53	6.6— 7.8	4 16.6	5 4;	23	22;		3 7;		22 1	
RZ Centauri	12 55.6	−64 05	8.5— 8.9	0 22.5	7 15;	22	15;		7 16;		22 16	
W Virginis	13 20.9	− 2 52	9.0—10.0	17 06.5	5 5;	22	12;		9 18;		7 1	
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	5 18;	19	19;		3 20;		24 22	
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	7 19;	24	5;		2 10;		18 21	
V Centauri	25.4	−56 27	6.7— 7.6	5 11.9	5 10;	21	22;		2 21;		24 21	
RS Bootis	29.3	+32 11	8.9—10.	0 09.1	1 3;	16	5;		1 8;		16 10	
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	6 4;	21	0;		5 20;		20 16	
R Triang. Austr	15 10.8	−66 08	6.7— 7.7	3 09.3	5 12;	19	2;		2 15;		22 23	
S Triang. Austr	15 52.2	−63 29	6.5— 7.5	6 07.8	5 22;	18	14;		1 5;		20 4	
S Normæ	16 10.6	−57 39	6.5— 7.4	9 18.1	6 3;	25	15;		5 9;		24 22	
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	2 13;	20	6;		8 0;		25 17	
RV Scorpii	16 51.8	−33 27	6.8— 7.6	6 01.5	5 12;	23	16;		5 19;		24 0	
u Herculis*	17 13.6	+33 12	5.1— 5.6	2 01.2	1 19;	20	6;		2 14;		21 1	
RV Ophiuchi*	17 29.8	+ 7 19	9.—< 11	3 16.5	4 9;	19	3;		3 21;		18 15	
X Sagittarii	41.3	−27 48	4.0— 6.0	7 00.3	1 18;	22	18;		6 19;		20 20	
Y Ophiuchi	47.3	− 6 07	6.2— 7.0	17 02.9	5 12;	22	15;		9 18;		26 21	
W Sagittarii	17 58.6	−29 35	4.8— 5.8	7 14.3	3 2;	18	7;		2 11;		17 16	
Y Sagittarii	18 15.5	−18 54	5.8— 6.6	5 18.6	3 6;	20	14;		2 3;		19 10	
U Sagittarii	26.0	−19 12	7.0— 8.3	6 17.9	3 16;	23	22;		7 9;		20 21	
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	3 0;	23	17;		4 1;		24 18	
Y Lyrae	34.2	+43 52	10.5—12.	0 12.1	5 2;	23	4;		5 6;		23 8	
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	5 18;	21	2;		1 7;		21 18	
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	1 5;	26	0;		5 22;		25 17	
β Lyrae *	46.4	+33 15	3.4— 4.5	12 21.8	10 11;	23	9;		6 7;		19 5	
κ Pavonis	18 46.9	−67 22	4.0— 5.5	9 02.2	11 0;	29	5;		8 7;		26 11	
U Aquilae	19 24.0	− 7 15	6.4— 7.1	7 00.6	6 13;	20	14;		4 16;		18 17	
XZ Cygni	30.4	+56 10	8.7— 9.3	0 11.2	4 18;	23	6;		2 14;		25 22	
U Vulpec.	32.2	+20 07	6.9— 7.6	7 23.5	4 15;	20	14;		6 13;		22 12	
SU Cygni	40.8	+29 01	6.6— 7.4	3 20.3	2 5;	17	14;		2 23;		18 9	
η Aquilae	47.4	+ 0 45	3.5— 4.7	7 04.2	3 18;	18	2;		2 11;		16 19	
S Sagittae	51.5	+16 22	5.6— 6.4	8 09 2	9 6;	26	0;		4 9;		21 4	
X Vulpec.	19 53.3	+26 17	8.5— 9.1	6 07.7	4 11;	23	10;		6 1;		25 0	
XX Cygni	20 01.3	+58 40	10.5—11.5	0 03.2	1 12;	21	18;		5 5;		18 17	
V Vulpec. *	32.3	+26 15	8.0— 9.0	37 19.0			15 8;				23 3	

Maxima of Variable Stars of Short Period not of the Algol Type.

Continued.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of minima in Sept.-Oct. 1912. d h d h d h d h
X Cygni	20 39.5	+35 14	6.4— 7.7	16 09 3	15 17; 2 3; 18 12
T Vulpec.	47.2	+27 52	5.5— 6.5	4 10.5	1 16; 23 20; 2 17; 24 21
WZ Cygni *	49.3	+38 27	9.8—10.8	0 14.0	1 8; 24 17; 6 10; 23 22
WY Cygni	52.3	+30 03	9.5—10.3	0 13.5	1 1; 23 11; 4 16; 21 12
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	2 0; 24 9; 3 8; 25 17
TX Cygni	20 56.4	+42 12	8 5— 9.7	14 17.4	3 10; 18 4; 2 21; 17 15
VY Cygni	21 00.4	+39 34	8.9— 9.5	7 20.6	2 6; 17 23; 3 17; 19 10
VZ Cygni	21 47.7	+42 40	8.4— 9.2	4 20.7	3 8; 22 18; 2 12; 26 20
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.6	2 17; 20 0; 7 7; 24 14
δ Cephei	25.5	+57 54	3.7— 4.9	5 08.8	3 11; 24 23; 5 16; 27 3
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	4 12; 26 6; 7 3; 28 21
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	7 6; 20 2; 2 22; 22 5
V Lacertae	44.5	+55 48	8.2— 8.9	4 23.6	5 9; 25 8; 5 7; 25 5
X Lacertae *	22 45.0	+55 54	8.2— 8.6	5 10.6	3 14; 25 9; 6 6; 22 14
SW Cassiop.	23 03.7	+58 12	9.2— 9.7	5 10.6	5 3; 21 10; 2 7; 24 0
RS Cassiop.	32.6	+61 52	9.1—10.0	6 07.1	3 18; 22 16; 5 6; 24 3
RY Cassiop.	47.2	+58 11	9.2—10.0	12 03.4	3 13; 27 19; 9 23; 22 2
U Pegasi	23 52.9	+15 24	9.0— 9.7	0 04.5	5 14; 20 14; 5 14; 20 14

Nova Geminorum No. 2.—A cablegram received at this observatory from Kiel states that a spectrogram of Enebo's *nova* obtained by Küstner at Bonn shows "dark lines uranium radium emanation."

EDWARD C. PICKERING.

Harvard College Observatory, May 29, 1912.
Astronomical Bulletin No. 492.

Variable Star 68 *u* Herculis.—In *A.N.* 4577 Mr. H. E. Lau gives some recent observations and a light curve of this variable star, which is of the β Lyræ type. The magnitudes at the different phases are as follows:

Chief minimum 1911 Sept.	6.79	Gr. M. T.	5m.27	Harvard
I Maximum	7.34	"	4 .68	"
Secondary minimum	7.86	"	5 .14	"
II Maximum	8.35	"	4 .74	"

Variable Star β Lyrae.—For β Lyrae Mr. Lau also gives a new light curve and correct date of minimum:

Chief minimum 1911 Sept.	11.86	Gr. M. T.	4m.32	Harvard
I Maximum	2.31	"	3 .45	"
Secondary minimum	5.58	"	3 .83	"
II Maximum	8.66	"	3 .45	"

New Variable Star 23.1912 Persei.—This was discovered by Rev. T. E. Espin. Its position for 1900.0 is

$$\alpha = 3^{h}\ 39^{m}\ 45^{s} \qquad \delta = +\ 52^{\circ}\ 21.'8$$

According to 11 observations between 1909 Dec. 18 and 1912 March 12 the star varies between magnitudes 8.9 and 10.5. The period appears to be long. The color of the star is red and its spectrum belongs to Class III or IV.

Two New Variables 24 and 25.1912.—These are announced by Mr. J. Palisa of Vienna, in *A. N.* 4573. Their positions for 1912.0 are:

	α	δ
	h m s	° ′ ″
24.1912 Leonis	9 39 28.70	+ 20 15 49.8
25.1912 Virginis	13 54 2.82	— 4 8 51.3

They are not in the BD and were found by comparison with photographs by Wolf, which show no stars in those positions. The following observations of the first show that it is waning quite rapidly.

1912 Feb. 18 $12^m.2$; Mar. 10 $12^m.8$; Mar. 21 $13^m.6$; Apr. 10 $14^m.5$. The second star was of magnitude 9.5 on April 15.

Variable Star 26.1912 Geminorum.—In *A. N.* 4578 Dr. A. Kühl of Munich says that the star BD + 32° 1414, which has been announced as a suspected variable, shows no signs of variability according to his observations, but that the star BD + 33° 1433 shows a range of about $0^m.4$ (from 7.08 to 6.68).

This is the star *d* on the charts given in our last number. Our own observations confirm to a certain extent those of Dr. Kühl. The star *a*, BD. + 32° 1414, shows no variation at all and the star *d* has a range of five steps or $0^m.4$, but as the latter star was very faint in the field glasses used, we place little reliance on the accuracy of the estimates made of its brightness.

New Variable 27.1912 Bootis.—This is announced by Mr. G. Demetresco in the *Comptes Rendus* 154, p. 1399. Its position for 1900 is

$$\alpha = 14^h\ 57^m\ 46^s \qquad \delta = +\ 24^\circ\ 53'\ 14''.$$

The variability was established by comparison of eight plates taken at Paris, on one of which, 1900 May 29 $10^h\ 26^m$ Paris mean time, the three images of the star were unequal, although the exposures were equal, showing the variation to be rapid. The star is faint, ranging between magnitudes 13 and 14.

BD.+ 32° 1414.—Having noticed in the last issue of POPULAR ASTRONOMY (p. 390), that the 5.8 mag. BD. + 32° 1414, (Suspected Variable 22.1912 Geminorum), has been suspected of variability, I determined to observe it for a few evenings and see if I could visually detect any changes of brightness in it. I was especially interested in watching the star on account of its having been one of my comparison stars during a number of my earlier observations of Nova (2) Geminorum, and consequently was desirous of finding out whether its supposed variations had any foundation in fact or not. The results of my observations of this star, (with 3-in. refractor), on the evenings of June 6, 7, 8 and 10, (unfortunately, due to its low position, it could not be followed after the last-named night), give a negative result in regard to any variability, as on every one of the evenings in question it was rated at mag. 5.8 ± (comp. stars, *θ*, BD. + 32° 1433 and 1437 Geminorum,) absolutely no changes of any sort having been detected in it. Its color, according to my judgment, is very light pink. I hold the alleged variability of this star very improbable.

FREDERICK C. LEONARD.

COMET AND ASTEROID NOTES.

Minor Planet 1911 MT.—Contrary to expectation, the faint hopes raised by the publication of the ephemeris by Messrs. Haynes and Pitman have been realized and images of the planet have been found upon three photographs taken with the 30-inch reflector at the Greenwich Observatory, and upon plates obtained at Heidelberg on October 17. In *The Observatory* for June 1912 Mr. Crommelin gives the following approximately corrected elements and ephemeris for 1911:

$T = 1911$ Aug. 31.4 Gr. M.T.
$\omega = 154°\ 1'$
$\Omega = 185\ 24$
$i = 8\ 32$
$\log a = 0.2756$
$\log e = 9.5903$
Period $= 2.5907$ years

The planet has the same perihelion distance as that of Eros 1.15 but an orbit of nearly double the eccentricity. It is to be hoped that still more images of the planet may be found, now that we have an approximately correct ephemeris.

Mr. J. Franz of Breslau published in *A. N.* 4575 a set of elements, agreeing remarkably well with the above, before the new positions of the planet were known.

Greenwich Midnight 1911	R. A. h m s	Decl. ° ′	log r	log Δ
July 31	21 20 56	+25 00	0.0763	9.3665
Aug. 4	30 35	25 51	729	.3431
8	41 12	26 33	697	.3196
12	21 52 55	26 54	671	.2972
16	22 05 36	26 52	0.0650	9.2764
20	19 11	26 27	634	.2575
24	33 28	25 36	622	.2401
28	22 48 18	24 15	616	.2258
Sept. 1	23 03 38	22 26	0.0614	9.2148
5	19 02	20 09	619	.2088
9	33 45	17 34	628	.2057
13	23 47 42	14 40	642	.2081
17	0 01 08	11 37	0.0662	9.2171
21	13 07	8 32	685	.2295
25	23 49	5 32	714	.2489
29	33 24	2 47	747	.2715
Oct. 3	41 56	+ 0 19	0.0784	9.2894
4	43 52	— 0 16	793	.3033
11	0 55 45	3 40	868	.3552
17	1 04 00	5 47	939	.4030
25	1 12 47	7 33	0.1043	9.4694
26	1 13 46	— 7 44	0.1057	9 4777

"The next opposition will be about March 1913, when the planet's magnitude will be 17 or 18. Most of its oppositions will take place in the neighborhood of aphelion, as it hurries over the nearer part of its orbit and lingers in the further part."

In the July number of *The Observatory* Mr. Crommelin says that the period indicated by later observations seems to be considerably longer than that given above. It may be as much as five years.

Return of Holmes' Periodic Comet in 1912.—In *A. N.* 4584 Dr. H. J. Zwiers gives an ephemeris of Holmes' comet extending from June 15 to August 2. The last four dates are as follows:

Greenwich Midnight	α h	m	s	δ °	′	″	log Δ
July 27	18	35	20.86	−46	47	58.3	0.2015
29		33	32.44	−46	28	09.8	0.2023
31		31	52.05	−46	07	29.0	0.2033
Aug. 2	18	30	20.08	−45	46	00.3	0.2046

The comet was nearest the earth on July 21. It is very faint and may possibly escape detection.

Ephemeris of Minor Planet 1911 MT.—About ten days ago Prof. Pickering sent to me elements of 1911 MT as per enclosed, computed by Mr. A.C.D. Crommelin of Greenwich. Professor Pickering wanted an Ephemeris computed and wanted to know time of next opposition. I send you my ephemeris based upon Crommelin's elements, which I trust may interest you. Next opposition March 16, 1913, distance from earth 1.559. This ephemeris is right if elements are right. (See note on preceding page.)

EPHEMERIS OF 1911 MT

1913	α h	m	s	δ °	′	″	log *r*	log Δ
March 15	11	44	9	−0	47	10	0.40720	0.19305
25	11	32	59	+0	54	43	0.40450	0 19102
April 4	11	22	41	+2	33	29	0.40152	0.19717
14	11	14	18	+3	59	31	0.39818	0.21015
24	11	6	45	+5	6	6	0.39452	0.22833
May 4	11	5	43	+5	53	8	0.39056	0.24973

F. E. SEAGRAVE.

PROVIDENCE, June 18, 1912.

COMMUNICATIONS QUESTIONS AND ANSWERS.

[This department is designed especially for the use of amateurs. Beginners are invited to send in their puzzling questions. The editors will try to see that answers are given to reasonable questions, but will not hold themselves responsible for the correctness of the views expressed in the communications which may find place here. All communications should be brief.]

Occultation of Antares.—I observed the occultation of Antares by the moon on the 26th of June. Immersion was at 9:22 and emersion at 10:53 Central time.

GUS A. DUERLER, JR.

San Antonio, Texas, July 3, 1912.

Occultation of Antares.—It may be of interest to your readers that the occultation of Antares by the moon was easily observed in Massachusetts. Two hours before the contact, the star was almost in line with the southern edge of the moon, but as the time approached it mounted higher and higher until at 11.26 P.M. it disappeared behind the dark limb at a point approximately 69° from the north. It reappeared at approximately position angle 320° at 12.08 A.M. The sky was cloudless, with Jupiter close by, watching the perfomance. A most charming sight especially to an amateur, who has never been fortunate enough to observe such an occurence before.

ALLAN B. BURBECK.

Occultation of Antares.—I observed the occultation of the star Antares from Westliberty (16 miles east of Iowa City, Iowa,) June 26. The star was occulted for 1 hour 18 minutes and about 10 seconds, from $9^h\ 39^m\ 50^s$ P.M. Central time. I was glad to observe it longer here than at Washington by about 4 minutes. The sun spot was of interest on June 23. I observed it to be 9560 miles in diameter according to my calculations.

JUDSON W. BRUSH.

Cedar Rapids, Iowa.
July 4, 1912.

Query:—I have always believed that the mass of Sirius and its companion exceeded that of the sun two and a half times, and that it was a little more than eight light-years distant. But Sir Oliver Lodge states in his "The Ether of Space" (Harper & Brothers, 1909) on page 130, that the mass of this star is twenty times that of the sun, and that it is twenty-four light-years distant. Is he right?

ANSWER:—The best recent computations give the parallax of Sirius as 0."376, the combined mass of Sirius and its companion as 3.33 times that of the sun, and the ratio of mass of the companion to that of the principal star as 0.39. These data yield for the distance of Sirius 8.6 light years and for the masses 2 40 and 0.93 times that of the sun. See also POPULAR ASTRONOMY Oct. 1910 p. 485 and this number p. 431.

NOTES FOR OBSERVERS.

The Monthly Report of the American Association of Variable Star Observers.*—The steady growth of the membership of the Association, and the increase in the number of observations sent in each month, is most gratifying to all interested in this practical line of observational work. In the eight months the Association has been at work, a total of 3319 observations have been published in POPULAR ASTRONOMY and sent to the Harvard College Observatory. From 200 observations, which was the total number in the first report, we have increased the number to 663 observations which are contained in this report; which speaks well for the activity and diligence of those coöperating in this plan, and our success should inspire many other observers to join our ranks.

During the past month we have gained two new members:—

Mr. H. C. Bancroft, Jr., 416 Taylor Av., West Collingswood, N. J.
Mr. Otto Mach, 21 Andrews St., Dayton, Ohio.

Observations made by these gentlemen will hereafter be indicated in the reports by the abbreviations "Ba" and "Ma" respectively.

The splendid set of 63 observations of the variable 103961 S Ursae Majoris, attests well the value of coöperation. All are urged to continue to observe this star whenever opportunity affords until further notice.

Special mention must also be made of the observations of 094211 R Leonis, 154428 R Cor. Bor., and the Nova Geminorum No. 2, which unfortunately is too close to the sun for observations at present.

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* Mr. Olcott's remarks in this report refer to the month of May-June only. The observations for the two months have been combined in one table. Ed.

VARIABLE STAR OBSERVATIONS May to July 1912.

001755
T Cassiopeiae

Mo.	Day	Est.	Obs
5	10	9.1	J
	10	8.8	L
	19	9.1	J
	25	9.1	J
	31	8.7	J
	31	8.8	L
6	3	8.4	S
	4	8.8	L
	6	8.9	J
	7	8.0	Y
	8	8.7	L
	18	8.5	S
	18	7.9	B
	30	9.1	J
7	2	7.8	B
	7	8.7	J

004958
W Cassiopeiae

5	10	10.2	J
	19	11.0	J
	25	10.7	J
	31	10.3	J
6	6	11.0	J
	14	11.3	J
	30	11.6	J
7	5	11.7	J
	6	11.4	J
	8	11.7	J

013238
RU Androm.

5	25	11.7	J
6	14	10.6	J
7	7	10.0	J

014958
X Cassiopeiae

6	3	10.8	Y
	12	11.2	Y

021403
o Ceti

6	17	4.2	F
	24	4.5	F
	27	4.7	G
	29	4.8	F

922150
RR Persei

6	3	11.2	Y
	12	10.8	Y

043065
T Camelop.

5	10	8.7	Y
	23	8.9	Y
6	7	9.5	Y

043274
X Camelop.

Mo.	Day	Est.	Obs.
5	10	8.2	O
	10	8.4	Y
	23	8.6	Y
6	5	10.1	Y

050953
R Aurigae

5	10	10.7	Y
	30	10.5	J
6	5	10.5	Y
7	7	10.4	J

053068
S Camelop.

5	17	9.0	Y
	25	8.9	Y
6	7	9.0	Y

054974
V Camelop.

5	10	10.0	O

054920
U Orionis

5	3	6.2	G

055353
Z Aurigae

5	10	10.3	Y
	23	10.9	Y
6	5	10.7	Y
	12	10.8	Y

060450
X Aurigae

5	11	8.3	Su

065355
R Lyncis

5	10	10.5	Y
6	3	12.5	Y

072708
S Can. Min.

5	4	7.7	G
	4	8.1	L
	6	8.0	L
	8	7.8	M
	9	8.1	L
	10	8.0	O
	10	7.9	B
	10	8.2	L
	11	7.8	G
	13	8.2	L
	13	7.9	M
	13	8.1	G
	17	7.9	M
	18	7.8	Ha
	29	7.0	G
	31	8.6	F

072811
T Can. Min.

5	11	10.2	Fu	5	4	5.2	L
	17	10.5	Fu		6	5.3	L
					7	5.3	L
073508					8	5.3	V
U Can. Min.					9	5.0	D
5	10	9.4	O		9	5.2	L
	10	9.0	Y		10	5.6	B
					10	5.5	O
073723					10	5.1	Y
S Gemin.					10	5.3	L
5	11	8.6	Fu		11	5.9	Su
	17	8.4	Fu		11	5.6	L
					11	4.9	G
081112					12	5.2	G
R Cancri					13	5.4	L
5	10	8.8	O		15	5.4	G
					18	5.8	V
081617					18	5.5	L
V Cancri					18	5.0	D
5	10	8.0	O		18	5.7	G
	11	8.2	Su		18	5.8	Ha
					19	5.5	O
083019					21	5.4	G
U Cancri					21	5.8	O
6	5	10.5	Fu		25	5.5	L
					25	6.5	V
084803					26	5.8	O
S Hydrae					26	5.6	L
5	10	8.5	O		27	5.5	L
	10	8.2	Hu		27	5.6	G
	17	8.2	P		28	5.7	Y
					28	5.5	B
085120					28	5.8	G
T Cancri					30	5.5	D
5	6	9.5	L		30	5.8	Ha
	8	9.0	Y		31	5.8	G
	9	9.5	L		31	5.7	L
	11	9.5	L				
	18	8.9	V				
	31	8.9	V	6	2	5.9	Ha
6	1	8.6	G		2	5.8	L
	4	9.4	L		3	6.0	Su
	7	8.8	V		3	5.8	G
	8	9.3	L		3	5.8	O
	11	9.3	L		5	5.7	B
	15	9.3	L		6	5.7	L
					7	5.8	Y
093178					7	5.8	G
Y Draconis					8	6.0	O
5	10	13.4	Y		8	6.1	Ha
6	3	13.6	Y		8	5.8	L
					9	5.9	G
093934					9	6.4	C
R Leo. Min.					11	5.9	L
5	10	11.2	Hu		13	5.9	B
	18	11.5	Hu		13	6.0	O
6	5	11.0	O		14	6.5	C
	5	11.0	Hu		15	5.9	G
	9	10.9	Hu		15	6.3	C
	14	10.9	Hu		15	6.0	L

094211
R Leonis

R Leonis

Mo.	Day	Est.	Obs.
6	16	6.4	C
	17	6.2	Ha
	20	6.8	F
	22	6.2	Ha
	28	6.0	G

103012
U Hydrae

6	7	5.3	C
	8	5.6	C
	9	5.6	C
	14	5.7	C
	15	5.7	C
	16	5.8	C

103769
R Urs. Maj.

5	17	12.6	Y
6	3	13.2	Y
	3	13.0	B
	8	11.8	Ba
	13	12.0	O
	14	12.0	Ba

104814
W Leonis

6	12	12.7	Y

105517
R Crateris

5	12	9.5	G
6	3	9.4	G
	7	9.4	G

110506
S Leonis

5	10	10.3	Y
	11	10.7	Su
	31	11.8	Su
6	3	11.6	Y
	3	12.6	Su
	12	12.3	Y

115919
R Com. Ber.

6	5	9.6	O
	13	9.4	O
7	5	9.0	O

121418
R Corvi

5	18	11.5	Hu
6	2	10.5	G
	5	10.9	Hu

122001
SS Virginis

5	10	7.6	O
	16	8.4	G
	31	8.3	G
6	8	8.0	O
	16	8.2	G
	18	8.6	O
7	4	8.6	O

VARIABLE STAR OBSERVATIONS May to July 1912—Continued.

122532
T Can. Ven.

Mo.	Day	Est.	Obs.
5	10	10.3	Y
	17	10.2	V
	28	9.8	Y
6	2	10.1	V
	3	9.8	Y
	5	9.7	Fu
	10	9.9	V
	12	9.7	Y
7	1	9.6	V

123160
T Urs. Maj.

5	8	9.0	L
	10	9.1	J
	10	9.2	O
	10	8.9	Hu
	11	8.6	Su
	12	9.5	D
	14	9.6	J
	17	9.2	G
	17	9.7	Y
	17	9.8	O
	17	9.8	Hu
	18	9.6	M
	18	9.8	S
	18	9.8	D
	18	9.7	B
	20	10.1	J
	27	9.8	M
	27	10.2	J
	28	10 9	B
	30	9.5	G
	30	10.2	J
	31	10.6	Su
	31	10.8	L
6	1	10.9	Ba
	3	11.1	O
	3	10.9	Y
	4	11.0	M
	4	10.8	L
	5	11.0	Ba
	7	11.5	Hu
	7	10.0	G
	7	11.2	Y
	7	11.0	B
	8	11.2	Ba
	8	11.3	O
	9	10.8	G
	12	10.9	Hu
	12	11.4	Y
	13	11.5	O
	13	11.9	Ba
	15	11.4	G
	20	12.0	B
7	3	12.5	B

123307
R Virginis

5	8	9.3	V
	10	9.2	O
	10	9.0	Hu

R Virginis

Mo.	Day	Est.	Obs.
5	17	8.7	V
	17	8.9	O
	20	8.2	Hu
6	3	8.2	O
	3	8.5	V
	3	9.6	G
	5	8.3	Hu
	8	7.7	O
	10	7.8	V
	10	8.2	S
	18	7.6	O
7	4	7.3	O

123459
RS Urs. Maj.

5	25	8.5	Fu

123961
S Urs. Maj.

5	4	8.0	G
	8	8.2	L
	8	7.6	M
	8	7.8	V
	10	8.4	J
	10	8.3	O
	10	7.7	Hu
	10	8.4	G
	12	8.3	G
	12	7.5	D
	14	8.4	J
	14	8.1	V
	15	8.3	G
	16	8.0	M
	17	7.9	V
	17	8 3	O
	17	7.4	Hu
	17	8.1	G
	17	8.5	Y
	17	7.8	B
	18	8.1	Ha
	18	8.2	S
	18	7.5	D
	18	7.8	B
	18	8.2	G
	19	7.9	V
	20	8.3	J
	21	7.9	G
	25	7.6	V
	26	8.2	O
	26	8.2	J
	26	7.7	L
	27	8.5	M
	27	8.3	J
	27	8.0	G
	28	7.8	B
	29	8.3	G
	30	8.4	J
	30	7.6	V
	30	8.2	G
	30	8.2	Ha
	31	8.2	G

S Urs. Maj.

Mo.	Day	Est.	Obs.
5	31	7.6	Su
	31	8.0	L
6	1	7.9	Ba
	1	8.4	J
	1	7.2	S
	2	7.5	G
	2	8.2	Ha
	2	8.0	M
	3	7.3	G
	3	8.0	J
	3	7.7	V
	3	8.1	O
	3	8.0	Y
	4	8.1	L
	4	8.0	M
	5	7.8	Ba
	5	7 9	B
	6	7.9	J
	7	8.0	Y
	7	8.0	O
	7	7.9	B
	7	7.6	Hu
	7	7.4	G
	8	7.6	Ba
	8	8.6	M
	8	8.3	L
	9	7.3	G
10	7.7	V	
11	8.0	Y	
11	7.6	Hu	
12	7.6	Hu	
13	7.9	B	
13	8.2	J	
13	8.0	Ba	
13	8 0	O	
13	8.1	S	
14	7.5	G	
15	7.5	G	
15	7.9	Ha	
16	8.4	M	
16	8.0	G	
17	8.0	Ha	
18	8.0	O	
18	7.9	G	
18	8.2	S	
19	7.8	V	
19	8.4	L	
20	8.0	O	
20	8.0	B	
21	8 2	Ba	
22	8.0	Ha	
22	8.5	F	
22	7.8	V	
26	8.0	G	
27	8.1	B	
27	8.3	O	
28	8.4	M	
28	8.0	G	
28	8.4	Ba	
30	8.6	J	
30	8.5	Ba	

S Urs. Maj.

Mo.	Day	Est.	Obs.
	30	8.0	Hu
7	1	8.3	V
	2	8.5	Ba
	2	8.3	M
	3	8.4	Ha
	3	8.3	B
	3	8 6	J
	3	8.5	O
	5	8.6	V
	5	8.5	Ba
	5	8.9	J
	6	8.3	Ha
	6	8.5	O
	7	8.8	J
	9	8.8	O

124213
RU Virginis

5	8	9.2	V
	17	9.6	V
6	2	9.7	V
	10	10.6	V

124606
U Virginis

5	10	8.4	O
	11	7.8	Su
	15	8.6	G
	17	8.5	S
	17	8.5	O
	18	7.9	Ha
	31	8.4	Su
6	2	9.1	Ha
	3	7.3	G
	3	9.0	O
	3	7.6	G
	8	9.0	O
	13	9.6	S
	18	9.3	O

132202
V Virginis

5	11	11.3	Su

132422
R Hydrae

5	6	8.4	L
	9	8.5	L
	10	7.8	G
	15	8.4	G
	17	8.7	G
	21	8.8	G
	28	8.8	G
	30	8.8	G
	31	9.0	L
6	4	9.1	L
	7	9.0	G
	8	9.1	L
	10	9.0	G
	15	9.1	G
	15	8.9	F
	15	9.2	L
	19	9.1	G
	19	9.2	L

133273
T Urs. Min.

Mo.	Day	Est.	Obs.
5	25	10.8	Fu
6	1	11.2	Fu
	3	11.5	Fu

133633
T Centauri

6	17	7.8	G

134440
R Can. Ven.

6	5	7.8	P
	9	8.3	O
	14	8.1	S
	18	7 5	P
	20	7.9	O
7	2	7.3	Ba
	2	6.9	M
	4	7.2	O
	5	7.1	P
	9	7.7	O

141567
U Urs. Min.

5	10	8.4	J
	14	8.4	J
	19	8.4	J
	21	8.7	J
	22	8.4	S
	30	8.1	J
6	1	8 4	J
	3	8 6	J
	13	8.4	S
	14	8.6	J
	28	9.0	J
	30	8.8	J
7	3	8.9	J
	5	8.7	Ba
	7	9.1	J

141954
S Boötis

7	6	11.5	J

142205
RS Virginis

6	8	12.1	L
	15	11.0	L
	19	10.3	L

142584
R Camelop.

6	4	11.1	L
	5	11.3	O
	7	10.6	B
	8	10.6	L
	9	10.6	O
	11	10.2	L
	13	10.3	O
	13	10.0	B
	15	10.0	L
	18	10.0	O
	19	9.7	B
	22	9.7	O
	27	9.2	B
	30	9.4	J

VARIABLE STAR OBSERVATIONS May to July 1912—Continued.

R Camelop

Mo.	Day	Est.	Obs.
7	3	9·5	O
	5	9.1	B
	7	8.9	J
	9	9.3	O

142539

V Boötis

5	9	8.3	L
	10	7.9	O
	10	8.6	G
	11	8.5	D
	13	8.0	D
	17	8.4	G
	17	8.5	V
	18	8.0	D
	18	8.1	S
	19	8.0	O
	29	8.5	G
	31	8 8	L
6	2	8.4	V
	5	8.6	L
	10	8.7	V
	10	8.6	G
	14	9.0	S
	15	9.0	F
	19	9.0	B
	22	9.1	F
	28	9.2	B
7	5	9.7	V
	5	9.2	B
	9	10.0	O

143227

R Boötis

5	4	9.2	G
	10	9 2	L
	10	9.2	O
	17	9 8	S
	19	9.7	O
6	3	10 8	G
	5	11.1	L
	18	10.5	P
	19	11.6	L
	20	11.2	B
7	5	11.0	P
	6	11.7	B

143417

V Librae

5	11	9.6	Su
	31	9.4	Su

150605

Y Librae

5	17	8.6	Hu
6	6	9.8	L
	8	10 0	Hu
	10	9.8	L
	14	10.0	Hu
	15	10.0	L
	22	10.7	L

151731

S Cor. Bor.

Mo.	Day	Est.	Obs.
5	10	9.7	O
	10	9.0	G
	18	9.7	G
	19	10.0	O
	31	10.7	G
6	7	10.8	G
7	3	10.8	Ba

153378

S Urs. Min.

5	6	11.6	L
	9	11.4	L
	11	11.6	L
6	4	11.9	L
	11	11.7	L

154428

R Cor. Bor.

5	4	7.2	G
	6	7.5	L
	9	8.0	L
	10	7.8	L
	10	7.7	J
	10	7.4	G
	11	7.9	D
	11	8.0	S
	11	7.2	Hu
	11	7.6	Su
	12	7.3	G
	13	7.4	L
	13	8.1	J
	15	7.3	G
	17	8.1	Y
	17	7.6	O
	18	7.2	Hu
	18	7.3	D
	18	7.5	Ha
	19	7.6	O
	20	7.6	O
	20	7.4	Hu
	21	7.5	O
	21	7.4	G
	25	7.6	Ha
	26	7.4	O
	28	7.2	G
	31	7.1	G
	31	7.3	Su
	31	6.9	L
6	1	6.8	J
	1	7.0	Ba
	2	7.0	G
	2	7.2	Ha
	3	7.1	G
	3	7.4	J
	3	7.3	S
	3	7.2	O
	3	7.1	Su
	5	6.8	L
	5	7.2	O
	5	7.0	Ba

R Cor.Bor.

Mo.	Day	Est.	Obs.
	5	6.9	Hu
	5	7.1	Y
	6	7.4	J
	7	6.8	G
	8	7.2	O
	8	6.8	Ba
	8	7.0	L
	8	7.4	Ha
	9	6.8	C
	9	6.9	O
10	7.0	G	
12	6.9	Y	
12	6.9	Hu	
13	6.9	O	
13	7.0	Ba	
14	7.1	J	
14	7.0	C	
15	6.9	F	
15	7.0	G	
15	7.1	Ha	
16	6.8	C	
17	6.9	C	
17	7 0	Ba	
18	7.2	S	
18	6.9	Hu	
19	6.8	L	
21	6 8	Ba	
22	6.9	O	
22	7.0	F	
24	7.0	F	
25	6.8	C	
27	7.2	O	
28	6.8	Ba	
30	6.8	Ba	
30	6.9	Hu	
30	6.7	J	
7	2	6.8	Ba
	3	6.7	J.
	3	6.4	M
	3	6.8	Ba
	3	6 8	Ha
	5	6.8	Ba
	6	6.8	J
	6	6.9	O
	7	6.6	J

154536

X Cor. Bor.

5	10	12.5	J
	13	11 8	J
	16	11.9	J
	20	11.8	J
	27	11.4	J
6	1	10.4	Fu
	3	10.6	J
	6	11.1	J
	14	10.3	J
	30	9.8	J
7	7	9.8	J

154615

R Serpentis

Mo.	Day	Est.	Obs.
5	10	6.8	O
	11	7.2	G
	16	6.8	G
	18	6.8	G
	19	6.4	O
	26	6.4	O
6	1	6.4	G
	3	6.3	G
	5	6.4	O
	8	6.6	O
	13	6.0	O
	15	6.3	G

155847

X Herculis

5	4	6.6	L
	6	6.3	L
	9	6.1	L
6	5	6.1	L

155823

RZ Scorpii

6	14	8.2	G
	16	8.2	G
	17	8.0	G

160210

U Serpentis

5	10	9.3	O
	18	10.6	V
	19	10.0	O
6	4	11.1	V
	17	7.4	G

161138

W Cor.Bor.

7	3	12.0	Ba

162119

U Herculis

5	9	11.0	M
	10	11.4	O
	10	10.5	Y
	12	11.0	D
	17	11.5	O
	19	11.3	Ha
	25	10.8	Y
6	5	11.5	O
	5	11.8	Y
	8	11.0	M
	8	11.6	Ba
	12	11.3	Y
	14	11.9	Ba

163137

W Herculis

5	18	9.8	Y
	18	9.5	S
	25	8.7	Y

W Herculis

Mo.	Day	Est.	Obs.
6	3	8.4	P
	3	8.4	P
	5	8.4	Y
	5	8.3	P
	11	7.9	Y
	18	7.8	S
	18	7.8	P

163172

R Urs. Min.

5	10	9.8	B
6	7	10.4	B
7	3	10.3	B

163266

R Draconis

5	6	8.2	L
	8	8 2	M
	9	8.2	L
	10	8.2	O
	11	8.3	L
	11	8.1	S
	11	8.3	M
	13	8.3	M
	14	8.8	J
	16	8.4	M
	17	8.4	M
	18	8.7	B
	18	8.7	Y
	19	9.0	O
	19	8.9	J
	22	8.7	M
	25	9.2	L
	26	9.3	O
	30	9.4	M
6	1	9.5	S
	1	9.5	J
	2	9.5	M
	2	9.7	L
	3	9.7	J
	3	10.0	Y
	4	9.5	M
	5	9.7	B
	5	10.2	O
	7	10.2	Y
	14	10.7	J
	17	10.2	C
	19	9.3	L
7	3	11.8	B

164715

S Herculis

5	10	10.1	O
	14	10.4	G
	18	10.4	J
6	3	10.5	O
	13	11.1	Ba
7	5	11.8	Ba

165030

RR Scorpii

6	1	9.2	G
	7	8.8	G
	19	8.6	G

VARIABLE STAR OBSERVATIONS May to July 1912.—Continued.

170215
R Ophiuchi

Mo.	Day	Est.	Obs.
5	10	10.7	G
	10	9.8	J
	14	10.3	J
	17	11.0	G
	19	10.5	J
	20	10.6	J
	21	10.8	G
6	5	11.2	J
	9	12.0	Ba
	14	12.0	Ba

171401
Z Ophiuchi

Mo.	Day	Est.	Obs.
6	3	8.2	O
	8	8.3	V
	19	7.7	V

175458
T Draconis

Mo.	Day	Est.	Obs.
6	7	10.7	V

180531
T Herculis

Mo.	Day	Est.	Obs.
5	10	11.5	O
	10	11.2	L
	17	10.4	O
	17	11.0	G
	19	11.5	Ha
	21	9.8	M
	22	9.8	M
	25	9.8	M
	25	9.5	L
	26	9.5	O
	27	9.6	M
	31	9.5	G
6	1	9.3	M
	2	9.2	G
	2	9.0	M
	2	8.8	L
	3	9.2	S
	3	8.7	C
	3	9.0	O
	3	9.0	M
	4	8.7	C
	4	8.8	L
	5	9.0	O
	6	8.7	C
	7	9.1	G
	7	8.8	C
	8	8.9	O
	8	8.8	M
	8	8.7	Ba
	8	8.7	L
	8	8.8	C
	8	8.6	V
	9	8.7	C
	11	8.3	M
	13	8.7	O
	14	8.6	Ba

T Herculis

Mo.	Day	Est.	Obs.
	14	8.7	C
	15	8 8	G
	15	8.7	C
	16	8.8	C
	16	8.7	M
	17	8.7	Ha
	17	8.8	C
	18	8 8	S
	20	8.6	M
	22	8.8	O
	22	8.8	V
	25	8.8	C
	29	8.7	G
7	2	8.9	M
	3	8.5	Ha
	3	9.1	O
	4	9.2	Ba

181136
W Lyrae

Mo.	Day	Est.	Obs.
5	10	7.8	O
	11	7.7	G
	17	7.7	O
	18	7.8	G
	18	7.5	Y
	20	7.6	O
	25	7.5	Y
	26	7.3	O
	27	8.2	G
6	3	7.8	O
	5	7.8	O
	7	7.9	Y
	7	7.9	G
	8	7.8	O
	8	7.9	G
	12	7.8	Y
	13	7.8	O
	15	8.3	G
	18	8.4	P
	20	8.3	O
	23	8.3	O
	29	8.5	G
7	3	9.2	O
	3	9.1	Ba

184205
R Scuti

Mo.	Day	Est.	Obs.
5	16	5.0	G
	21	5.0	G
	29	5.5	G
6	2	6.0	G
	7	5.9	G
	9	5.9	G
	14	6.0	G
	15	5.8	F
	22	5.3	O
	28	6.0	G
7	5	5.6	O

190967
U Draconis

Mo.	Day	Est.	Obs.
6	18	12.0	Hu

193449
R Cygni

Mo.	Day	Est.	Obs.
5	6	11.3	L
	10	11.4	L
	16	11.3	F
	18	9.5	D
	23	11.4	F
6	8	11.9	Ba
	22	13.0	Hu

194048
RT Cygni

Mo.	Day	Est.	Obs.
6	8	12.0	Ba
	13	11.9	Ba
	22	10.8	Hu
7	2	10.8	Ba

194348
TU Cygni

Mo.	Day	Est.	Obs.
5	6	10.4	L
	16	11.2	F

194632
X Cygni

Mo.	Day	Est.	Obs.
5	14	11.8	J
	27	11.3	J
6	3	11.0	O
	6	10.9	J
	13	11.0	O
	14	10.4	J
	15	11.0	F
	18	11.0	O
	21	10.5	Ba
	22	10.8	O
	27	10.5	O
	28	10.6	G
	30	10.2	J
7	2	11.2	Ba
	3	10 5	O
	7	10.1	J

200525
W Vulpeculae

Mo.	Day	Est.	Obs.
6	18	9.5	G

200647
SV Cygni

Mo.	Day	Est.	Obs.
5	30	8.5	G
6	1	8.6	G
	7	9.0	G
	11	8.5	F
	13	9.0	O
	15	8.7	F
	15	8.8	G
	20	9.0	O
	20	8.8	F
	26	8.7	G
	28	8.5	G
	29	8.6	F
7	6	8.7	O

200938
RS Cygni

Mo.	Day	Est.	Obs.
5	10	9.3	J
	16	8.0	F
	18	8.9	J
	21	8.0	G
	27	8.3	G
	30	8.5	J
6	1	8.9	J
	3	8.2	O
	5	8.9	J
	8	8.2	O
	9	7.5	G
	13	8.0	O
	15	7.7	G
	20	7.9	F
	22	8.0	O
	28	8.3	J
7	1	8.2	J
	7	8.2	J

201008
R Delphini

Mo.	Day	Est.	Obs.
5	10	8.9	J
	14	8.7	J
	25	8.9	J
	30	9.2	J
6	5	9.6	J
	9	10.1	O
	14	10.0	J
	18	10.0	O
	30	11.1	J
7	3	11.6	Ba
	6	11.1	O

201130
SX Cygni

Mo.	Day	Est.	Obs.
5	10	13.3	Y

201647
U Cygni

Mo.	Day	Est.	Obs.
5	6	8.0	J
	10	8.2	J
	11	7.7	G
	11	8.4	S
	16	7.7	G
	16	7.1	F
	19	9.0	J
	20	7.8	O
	21	7.8	G
	26	7.5	O
	27	7.7	G
	27	8.3	L
	27	7.5	O
	30	8.2	J
	30	7.8	G
	31	8.0	F
6	1	8.6	J
	1	7.9	G
	2	7.8	G
	3	7.8	O
	5	9.0	J

U Cygni

Mo.	Day	Est.	Obs.
	8	7.8	O
	8	8.3	L
	9	8.9	C
	10	8.6	S
	11	7.8	F
	13	7.8	O
	14	7.8	G
	15	9.0	C
	16	9.1	C
	17	9 0	C
	19	7.8	G
	20	7.8	O
	20	7.8	F
	22	7.8	O
	25	8.4	C
	26	7.8	G
	27	7.8	O
	28	8.9	J
	29	8.0	F
7	1	8.7	J
	6	7.8	O
	7	9.0	J

203816
S Delphini

Mo.	Day	Est.	Obs.
5	10	9.3	Y
	23	9.9	Y
6	3	9.7	Y
	12	9.7	Y

203847
V Cygni

Mo.	Day	Est.	Obs.
5	20	10.5	O
6	7	9.8	O
	18	9.8	O

204405
T Aquarii

Mo.	Day	Est.	Obs.
5	10	7.7	J
	19	7.1	J
	25	7.5	J
6	1	7.6	J
	5	7.7	J
	5	8.8	V
	14	7.7	J
7	3	9.0	J
	7	9.3	J

204846
RZ Cygni

Mo.	Day	Est.	Obs.
6	7	11.9	Y
	12	11.7	Y

205923
R Vulpeculae

Mo.	Day	Est.	Obs.
6	5	11.2	J
	13	10.7	J
	30	9.7	J
7	4	9.5	O
	7	9.5	J

VARIABLE STAR OBSERVATIONS May to July 1912.—Continued.

210868
T Cephei

Mo.	Day	Est.	Obs.
5	4	8.8	L
	6	8.8	L
	10	8.8	L
	17	9.0	O
	17	8.0	B
	18	9.1	J
	18	8.3	Ha
	26	8.4	O
	27	8.4	L
	30	8 5	J
6	1	8.6	J
	2	7.9	Ha
	2	8 6	L
	3	7.9	B
	3	8.8	O
	4	8.7	M
	5	8.9	Ba
	6	8.4	L
	6	8.6	J
	7	8 4	O
	8	8.2	M
	8	7.9	Ba
	11	8.3	L
	13	7.6	B
	13	8.1	Ba
	13	8.2	O
	14	8.3	S
	14	8.5	J
	15	8.3	L
	16	8.2	M
	17	7.7	Ha
	20	7.7	B
	20	8.1	M
	20	8.2	O
	22	7.6	Ha
	22	8.3	L
	22	8.1	O
	27	8.1	O
	30	8.4	J
7	2	7.7	M
	2	7.7	Ba
	4	8.2	O
	5	7.3	B

T Cephei

Mo.	Day	Est.	Obs.
	6	7.4	Ha
	7	8.2	J
	9	8.2	O

213044
W Cygni

Mo.	Day	Est.	Obs.
5	8	5.7	L
	10	5 7	L
	31	5 5	L
6	8	5.4	L
	10	5.5	G
	22	5.4	L

213553
RU Cygni

Mo.	Day	Est.	Obs.
5	21	8.8	G

213678
S Cephei

Mo.	Day	Est.	Obs.
5	17	9.0	O
	17	8.3	B
	19	9.3	J
	19	8.7	Ha
	26	9.4	O
6	1	9.5	S
	1	9.4	J
	3	8.6	B
	3	9.0	O
	6	9.3	J
	7	9.5	O
	13	8.6	B
	13	9.4	O
	14	9.8	S
	17	9.3	Ha
	20	8.3	B
	20	9.6	O
	20	10.0	M
	22	8.6	Hu
	28	8.4	B
	30	9.5	J
7	5	9.7	O
	6	8.8	B
	8	9.9	J

213843
SS Cygni

Mo.	Day	Est.	Obs.
5	10	12.1	Y
	10	11.9	J
	13	11.9	J
	16	11.4	F
	18	11 6	J
at 12:45 a.m.			
	18	8.9	J
at 11:45 p.m.			
	19	8.4	J
	20	8.2	J
	21	8.6	G
	22	8 2	J
	25	8 4	J
	27	8.5	J
	29	8.6	G
	30	9.3	J
	31	10.0	G
6	1	10.1	J
	2	11.0	G
	3	10.9	J
	5	11.9	J
	7	11.9	J
	8	11.9	Ba
	12	12.1	Hu
	13	12.0	J
	13	12.0	Ba
	14	12 1	Hu
	18	12.1	Hu
	30	11.9	J
7	2	11.9	J
	3	11.9	J
	5	11.9	J
	6	12.0	J
	7	11.9	J
	8	11.9	J

213937
RV Cygni

Mo.	Day	Est.	Obs.
5	16	7.1	G
	21	7.1	G
	29	6.9	G

RV Cygni

Mo.	Day	Est.	Obs.
6	2	6.9	G
	7	7.1	G
	9	8.2	C
	10	7.2	G
	14	8.4	J
	15	8.0	F
	15	8.3	C
	16	8.3	C
	17	8.3	C
	18	7.2	O
	22	8.0	F
	25	8.1	C
	30	8.4	J
7	8	8.5	J

215934
RT Pegasi

Mo.	Day	Est.	Obs.
6	3	11.8	Y
	12	11 9	Y
	22	12.4	39

S Lacertae

Mo.	Day	Est.	Obs.
5	10	9.6	Y
	23	8.6	Y
6	3	8.5	Y

230759
V Cassiopeiae

Mo.	Day	Est.	Obs.
5	10	11.7	J
	25	11.9	J
6	5	12.1	J
	14	11.9	J
	22	11.0	F
	29	10.9	F
	30	11.4	J
7	6	10.6	J
	7	11.0	J

233335
ST Androm.

Mo.	Day	Est.	Obs.
7	5	10.3	O

235350
R Cassiopeiae

Mo.	Day	Est.	Obs.
5	9	7.8	L
	10	7.4	J
	19	7.5	J
	25	7.4	J
	31	7.3	L

R Cassiopeiae

Mo.	Day	Est.	Obs.
6	1	7.3	J
	4	6.7	L
	6	7.6	J
	8	6.7	L
	14	7.9	J
	15	7.4	L
	20	7.1	B
	22	7.7	L
	30	7.9	J
7	7	8.0	J

235939
SU Androm.

Mo.	Day	Est.	Obs.
6	3	12.2	Y

Nova Gemin.

Mo.	Day	Est.	Obs.
5	4	7.2	G
	4	7.2	L
	6	7.3	L
	8	7.5	M
	9	7.3	L
	10	7.5	G
	10	7.4	O
	11	7.2	L
	12	7.4	G
	13	7.3	L
	13	7.9	G
	15	8.1	G
	17	7.5	O
	17	8.2	G
	17	8.3	M
	18	7.4	Ha
	19	7.5	Ha
	21	8.1	G
	27	7.1	L
	27	8.0	G
	29	8.2	G
	30	8.1	G
	30	7.6	Ha
	31	7.2	L
6	1	8.7	G
	1	8.1	G
	2	7.1	L
	3	8.2	G
	4	7.2	L
	8	7.3	L

Hartwig calculated a maximum for the variable 180531 T Herculis, for June 6, which appears to be in error, as the observations indicate that the star was close to the ninth magnitude and rising on that date.

The calculated date (June 9) of the maximum of the variable 201008 R Delphini also fails of verification, as on said date the star was about the tenth magnitude and waning.

A maximum of 235350 R Cassiopeiae was calculated for May 20, and was observed by Mr. Jacobs a little later than that date, but apparently the variable fell far short of its greatest recorded brilliance given in Hartwig's catalogue as 4.8.

The feature of this report is the fine set of observations of 213843 SS Cygni by Mr. M. W. Jacob's Jr., of Harrisburg, Pa. Mr. Jacobs was fortunate in observing the sudden rise of this wonderful star May 18, when at 12:45 a.m. his estimate of its magnitude was 11.6; the same day at 11:45 p.m. he again observed the star and found that it had risen to the 8.9 magnitude, an increase of about twelve times in brilliance in less than twenty-four hours. On May 20 the variable reaches its maximum magnitude, 8.2, and the next night Dr. Gray observed it through rifts in drifting clouds, and estimated its magnitude as 8.6. This variable is due for another display of activity about August 10 and it is hoped that many members of the association will be fortunate enough to observe its rise. The observations of this variable are especially valuable and every effort should be made to observe it frequently.

The variable 154428 R Cor.Bor. has been well followed by our observers during the past month, with a close agreement in the observations. This star seems to have fluctuated within the narrow limits of one magnitude, the seventh. This is a star that should be observed often as it is extremely irregular.

There is the usual divergence in the observations of the red variables, 201647 U Cygni, 200938 RS Cygni, and 213678 S Cephei. The different methods of observation being clearly indicated by the record.

The writer wishes to thank the members of the association for furthering the advancement of the work by sending tracings of the variable charts to the new members, as in this way much good has been accomplished and a friendly spirit promoted which has brought us all closer in touch with each other.

WILLIAM TYLER OLCOTT.
Corresponding Sec'y.

Norwich, Conn.
June 10, 1912.

GENERAL NOTES.

The next number of POPULAR ASTRONOMY will be the October number.

Dr. Lewis Boss, director of Dudley Observatory, has received the degree of doctor of science from Dartmouth College.

Professor George E. Hale, director of the Solar Observatory of the Carnegie Institution, has received the degree of doctor of laws from the University of California.

M. C. André, director of the Lyons Observatory, has died at the age of seventy-two years.

Professor W. J. Hussey, director of the observatory of the University of Michigan, received the honorary degree of doctor of science from Brown University at the last commencement.

Professor Edwin B. Frost, director of the Yerkes Observatory, has received the degree of doctor of science from Cambridge University.

Professor Joel Stebbins, director of the University of Illinois Observatory has been granted a sabbatical leave of absence and will spend the coming year in Europe visiting various observatories. He will remain for a semester or more at Munich.

We hope to have occasional notes from him concerning matters which he shall find of special interest during the year.

Professor Charles L. Doolittle, director of the Flower Astronomical Observatory of the University of Pennsylvania, received the honorary degree of doctor of laws at the annual commencement of Lehigh University.

Professor S. A. Mitchell, of Columbia University, will spend a year at the Yerkes Observatory.

Mr. Reynold K. Young (A. B., Toronto '09), for the past three years fellow in the Lick Observatory, has been appointed instructor in astronomy and physics in the University of Kansas. Mr. Young takes his doctor's degree from the University of California in June (*Science* May 31, 1912).

Mr. H. C. Plummer has been elected royal astronomer in Ireland, in succession to Dr. E. T. Whittaker, who was recently elected professor of mathematics at Edinburgh University. Mr. Plummer is the son of W. E. Plummer, director of the Liverpool Observatory, and has been second assistant to Professor H.H. Turner at the Oxford University Observatory since 1901.

Professor Jules Henri Poincaré, mathematician and cousin of the French premier, died suddenly yesterday in Paris of embolism. He was a professor of science at the Paris University, a member of the Institute and of the French Academy, inspector general of mines and a corresponding member of the Academy of Sciences at Washington, as well as of all the academies of science of Europe. He was 58 years old. (Chicago Record-Herald, Aug. 18, 1912).

International North Atlantic Weather Service.—The plan of Professor Willis L. Moore, chief of the United States Weather Bureau, for the establishment of an international North Atlantic weather service has been agreed to by the committee of the Radio Telegraph Congress meeting at London. According to the plan as outlined by Professor Moore, a median line will be established through the North Atlantic. All ships on either side of the line must take a daily weather observation which will be sent by wireless telegraphy to other vessels and thus relayed to the American or European land stations. From these reports weather charts will be constructed and forwarded to the shipping at sea (*Science* July 5, 1912).

The National Argentine Observatory.—A communication from Director C. D. Perrine to *Science* (June 28, 1912) announces that the Argentine Congress has provided in its budget for 1912 a 5-foot reflecting telescope for the National Observatory at Córdoba.

It is expected to locate this telescope in the mountains to the west of and close to Córdoba, where the meteorological conditions have been found to be good.

Astronomical Mail Lost on the Titanic.—Copies of the *Astronomische Nachrichten* No. 4565, No. 5 Band 191, mailed to subscribers in North America were lost on the steamer Titanic. A new edition of that number has been printed and sent to these subscribers.

It seems probable also that the April number of *The Observatory* for American subscribers was lost at the same time.

Preliminary Radial Velocities of 212 Brighter Class A Stars. In the Lick Observatory Bulletin, No. 211, Professor Campbell publishes the list of radial velocities which have been determined with the Mills spectrographs at the Lick Observatory and at Santiago, Chile, for stars of the spectral Class A. The list comprises 212 stars, for which fair determinations of the velocity in the line of sight are available, although a considerable number of them are marked as uncertain.

From this system of stars Professor Campbell finds the most probable velocity of the sun, to be 15.3 km. per second, assuming the apex of its motion to be situated at $\alpha = 270°$, $\delta = +30°$. This is 4 kilometers less than the velocity from the class B stars in 1911 and from 1193 stars of all classes in the same year. Professor Campbell thinks that the difference is perhaps no greater than should be expected from different lists of stars of so small a number.

When the motion of the sun is eliminated the average motions of the the Class A stars are found to be as follows.

98 stars	Class A	Average numerical velocity 10.27km.
67 stars	Class A_1—A_4	Average numerical velocity 11.38
47 stars	Class A_5—A_9	Average numerical velocity 12.58
212 stars	Class A—A_9	Average numerical velocity 11.1 km.

There appears thus to be some evidence that the average velocities increase with advancing subdivisions in Class A.

With reference to Kapteyn's vertex of preferential motion at $\alpha = 93$, $\delta = +12°$, these stars show a tendency to increased velocities the less their distance from that vertex. The velocities also appear to be functions of the galactic latitude of the stars, i. e. they decrease with distance from the Milky Way.

Professor Campbell publishes not only the radial velocities of these stars but also other data useful to those who wish to enter into the statistical study of star motions, such as the distance and direction of the solar apex from each star, the star's proper motion and its components in the direction of the solar apex and at right angles to that direction.

Spectrographic Observations of Nova Geminorum No. 2.—In *A. N.* 4582 Mr. H. Giebeler of the Bonn Observatory gives the results of measurement of 10 spectrograms taken with the 30 cm. refractor and Toepfer three prism spectrograph from March 14 to April 4, 1912. The hydrogen line at λ 3969 yields for the radial velocity of the Nova +7.0 kilometers, with a probable error of ±2.8 km. Mr. Giebeler finds many fine absorption lines in the spectrum and identifies 12 lines as probably coinciding with the lines of radium, 4 with uranium, and 6 with "emanation" lines. This is the first time that these lines have been identified in stellar spectra. Professor H. Kayser in *A. N.* 4583 comments upon the fact that we have here for the first time knowledge of radio-active substances in enormous quantities in space, and discusses the explanation of new stars through radio-active processes.

Rotation of Uranus.—In the Lowell Observatory Bulletin No. 53. Dr. Lowell and Dr. Slipher give the results of measurement of spectrograms of the planet Uranus, taken by Dr. Slipher on seven nights in August and September 1911, for the purpose of determining the period of rotation of the planet. The markings upon the disk of Uranus have been too vague to give any very certain suggestion as to the planet's rotation, even the position of its equator being unknown, but being assumed to be practically coincident with the plane of the orbits of the satellites.

The spectrographic method of determining the rotation of so small a disk is an extremely delicate one, and unfortunately, ever since the spectroscope became capable of attaching the problem, the planet has been in such a position as to present its south pole toward us. With a pole pointing toward the observer there can be no radial motion, either of approach or recession, resulting from the rotation. The pole of Uranus in 1902 was pointing nearest toward the earth and has since been gradually turning away so that now the radial effect of rotation is becoming appreciable. It will not reach its maximum for another ten years yet.

In spite of the unfavorable situation of the planet the spectrograms show a small inclination of the lines, for which Dr. Lowell and Dr. Slipher obtain quite accordant measures.

The average from the spectrograms on the seven nights yields for the period of rotation

$$10^h\ 50^m,$$

the rotation being in the same direction as the revolution of the satellites in their orbits.

Astronomy in a Nutshell, by Garrett P. Serviss, xi + 261 pages, published by G. P. Putnam's Sons, New York. Price $1.25 net.

Like all of Mr. Serviss' books, this is written in simple language and popular style. It presents the subject of astronomy in a succinct popular form, including all that any well educated person who does not care to pursue the science in detail would probably care or need to know. No mathematical knowledge beyond the simplest outlines is assumed on the part of the reader. The book is intended for readers of all ages who desire a sufficiently comprehensive knowledge of the subject to understand the operations of astronomers and to read intelligently the books and articles in which the results of such operations are referred to.

An Introduction to Mathematics, by A. N. Whitehead, 256 pages, published by Henry Holt and company New York. Price 75 cts, net.

The title of this book will appear to be a misnomer to most who read it, for it can be read with profit only after one had taken the usual courses in mathematics taught in high school and college. It does, however, present some clear explanations of the fundamental principles of mathematics, about which most students and many teachers have rather vague ideas. The book will be useful to teachers and to students who are going on to the study of higher mathematics.

Publications Received.

Theories of World Making, Alfred T. DeLury.

Determination of the Depth of the Milky Way, T. J. J. See.

Het Nut der Sterrekunde, Dr. A. A. Nijland.

On certain Expansions of Elliptic, Hyperelliptic and related Periodic Functions, F. R. Moulton.

Publicationen des Haynald-Observatoriums, Heft X. Protuberanzen beobachtet in den Jahren 1891, 1892, von J. Fényi, S. J. Kalocsa.

Adopted photographic magnitudes of 96 polar stars, Edward C. Pickering, Harvard Circular 170.

Five variable stars having secondary minima, Edward C. Pickering, Harvard Circular 171.

Photographic magnitudes of Asteroids, Edward C. Pickering, Harvard Circular 172.

Periods of 25 variable stars in the Small Magellanic Cloud, Edward C. Pickering, Harvard Circular 173.

Tests of photographic plates, Edward S. King, Annals of Harvard College Observatory, Vol LIX, No. IX.

An observing list for the determination of the relative masses in visual binary stars, R. G. Aitken, Lick Observatory Bulletin 208.

The spectrum of comet Brooks 1911 c, W. H. Wright, Lick Observatory Bulletin 209.

Solar parallax papers 6–9, Arthur R. Hinks.

Abhandlungen herausgeben von Naturwissenschaftlichen Verein zu Bremen, XXI Band, I Heft.

The three-prism stellar spectrograph of the Mount Wilson Solar Observatory, Walter S. Adams, Contributions Mt. Wilson Solar Obs. No. 59.

The effect of pressure upon electric furnace spectra, second paper, Arthur S. King, Contributions Mt. Wilson Solar Obs. No. 60.

The Spectra of 745 double stars, Annie J. Cannon, Annals of Harvard College Obs., Vol. LVI, No. VII.

1659 new nebulae, Solon I. Bailey, Annals of Harvard College Obs., Vol. 72, No. 2.

Miscellaneous photographic investigations, Edward S. King, Annals of Harvard College Obs., Vol. LIX, No. 10.

Variability of the pole star, Edward C. Pickering, Harvard Circular 174.

Pubblicazioni della Specola Vaticana, Vols. VI and VII.

Results of observations made at the Coast and Geodetic Survey magnetic observatory near Honolulu, Hawaii, 1909-1910, Daniel L. Hazard.